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THE GLASS-SPONGES.

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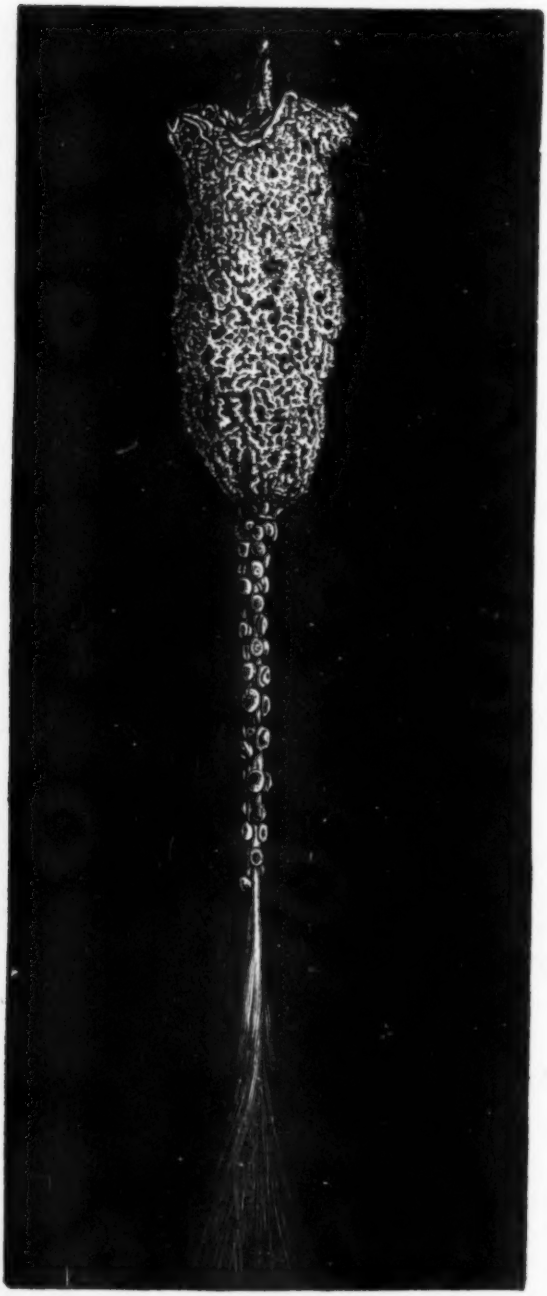
MY attention was absorbed in the study of an object contained in a vessel of sea-water that stood upon the table. It was clad in a suit of vermilion velvet, which, with its branching form, made it not unlike the precious red coral of the Mediterranean. I had been trying with a lens to see the water-current leaving the exhaling orifice. Observation was arrested; for it had become evident that the heated condition of the water had smitten my little beauty with death. "Please tell me the name of that pretty plant," said a visitor. The reply was: "Sir, that is not a vegetable, but an animal structure. It is a dying sponge." The question has been long mooted, whether the sponge was an animal or a plant. In Japan it is called "sea-cotton;" and, until recently, this vegetable view was held even in scientific circles. Prof. H. James Clark, the learned author of "Mind in Nature," so long ago as 1857, unfolded with remarkable clearness the peculiar cell-structure of the sponge. Last year an English naturalist, H. J. Carter, fed a living calcareous sponge with indigo, then made out the cells with the coloring-matter contained. He declares himself to have fully confirmed what Prof. Clark had written. Both agree in regarding the sponges as a group in that division of the animal kingdom known as the Protozoa, and nearly allied by their uniciliated cells to the Flagellate Infusoria. These infusoria are very minute animalcules, which have certain cilia, or hair-like appendages, by which, with a lashing motion, they propel themselves through the water. Each sponge-cell has one lash, or *cilium*. Indeed, this cell has a sort of individuality of its own, and yet millions of these almost infinitesimal one-celled beings are united to make up the one zoological individual known as a sponge. But, as the sponge-mass is fixed, and cannot travel, why should its cells be ciliated at all? Have they any whipping to do?

FIG. 1.



HYALONEMA LUSITANICUM, THE GLASS-ROPE SPONGE. Half the natural size. The brush-like threads at the bottom form a twisted rope terminating in the teat-like projection at the top, where it is covered with fine sponge. This coil is the Glass-Rope. The sheath, or incrustation of little starry warts, is the work of a polyp, known as the *Palythoa fatua*. The conical head is a mass of sponge once called *Carteria*.

In a word, what is the function of this lash in each of these cells, which, combined, and taken with the skeleton, constitute a sponge? Let us try to see. If we take a morsel of a toilet-sponge, and put it under a microscope of moderate power, we find that it is made up of a mass of complicated net-work. There is more or less regularity in the meshes; and these are found of various patterns in the different species. This heap or mass of net-work, commonly called a sponge, is really the skeleton of the sponge. When living it is covered with, or literally embedded in, a glairy, gelatinous, or albuminous substance. But this is so unlike ordinary animal tissue—for it seems, really, tissueless—that it has received the technical name *sarcode*. This sarcode fills the meshes above mentioned; and is held in place by innumerable tiny spicules, mixed in, so to speak, like the hair in the mortar of the plasterer. So little consistency has this sarcode, or sponge-flesh, that but for this natural felting it would dissolve and flow away. Now, take an ordinary sponge into the hand. We observe several large apertures, at or toward the top. These are called the *oscula*. They are the exhalant vents of the entire system. At these openings is expelled, with some force, the water that has been taken into the living mass, and deprived of its nourishment. But how is the water brought in through that glairy sarcode? Besides the oscula, which are few, and readily seen, even in the skeleton, there are innumerable tiny inlets known as *pores*. These are not visible in the skeleton, as they really belong to the sponge-flesh. These pores open into the meshes, and enter directly certain little cavities, or chambers, that stand connected with circuitous passages, which finally lead to the large outlets, or oscula. The pores are very small, and yet, compared with the cells, are very large. The little chamber into which the pore opens has its walls built up with these uniciliated cells. Now, if we could only peep into the privacy of that chamber, with its walls of living stones, without making any disturbance, we should find every cell lashing its cilium with great vigor, and all in such harmony of accord, that it would seem like

> "Beating time, time, time,
> In a sort of Runic rhyme."

The beating of each lash is doubtless downward, that is, inward; the effect of which is, a *vacuum* above, into which the water presses through the external pore. A second result of this downward beating of the cilia from a myriad of cells is, the impulsion of the passing water through the ramifications leading to the oscula. Thus the running of the waters is the sponge's ancient "Runic rhyme." Every sponge, then, has a very complete aquiferous system: its conduits at, the entrance of and along which the busy one-lashed cells occupy themselves forcing the water along; and the oscula, which may be likened to the outlets of sewers. During this circulation of the fluid

through the living mass, the sarcode obtains its nourishment, and the skeleton its growth by a sort of absorption, or what is known to the physiologist as endosmotic action of the cells. We have then mentioned above three clearly specialized functions, as represented respectively by the inhalant pores, the exhalant oscula, and the uniciliated cells. And it is certainly a matter of prime importance that each cell should have this single lash. In fact, it raises it to the rank of a pacha with one tail, in a community where all are pachas of this dignity, and each one a commissioner of the water department, and a commissary of subsistence. "Both the oscula and pores can be closed at the will of the animal; but the oscula are permanent apertures; whereas, the pores are not constant, but can be formed afresh whenever and wherever required."

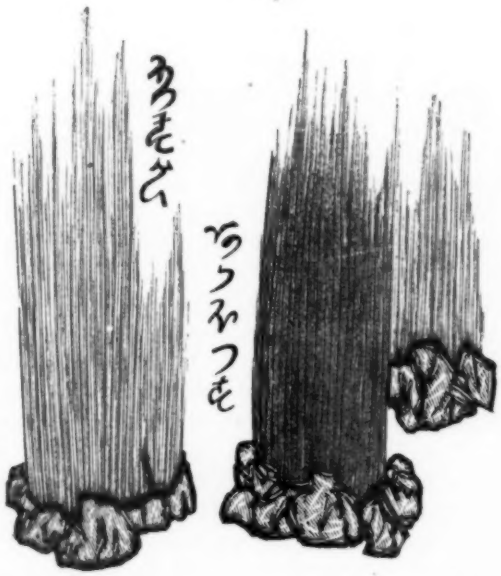
The sponges are the active eliminators of the salts of the ocean. In a large laboratory certain substances are kept in solution, so as to be ready to the chemist's hands. Nature's grand laboratory is the sea. There her little economic chemists are ceaselessly busy extracting, and putting into solid forms, the various mineral substances held in solution. Thus the coral polyps eliminate the carbonate of lime with which to build their beautiful structures. And the Alcyonarian polyp in this way builds up the delicate sea-fan, with its skeleton of keratose, or horn-like substance. And so is it with the sponges. They, too, are elaborators of the mineral treasures of the sea. Hence it has been attempted to group them upon considerations of their special building propensities. In this way the toilet-sponges, and, in general, those of commerce, which all affect horn, or keratose, in the structure of their skeletons, would be grouped together as the Keratosa; while those which choose lime would be called Calcarea; and those which build up with silex would be known as the Silicea. We have mentioned these groups in their order of rank. The highest is the vitreous, or glass-sponge, with which we are directly concerned.

In the recent deep-sea dredging, so charmingly described in Dr. Wyville Thompson's new book, "The Depths of the Sea," an account is given of the obtaining in British waters, at the depth of 30,000 feet (!), specimens of the Hyalonema, the famous Glass-Rope Sponge. It had been previously obtained from the coasts of Portugal, when the news astonished naturalists, as previously it had only been known as coming from Japan. It is, indeed, a wonderful object. We once saw a specimen in the cabinet of a learned institution. The professor pronounced it a coil of Japanese spun glass. "No," said another *savant*, "it is a plant." And at that time both were excusable, for even Ehrenberg had looked upon it as "an artificial product of Japanese industry." That is to say, the great microscopist regarded the object as an ingenious imposition, consisting of natural products artfully put together. Let the reader carefully inspect the cut of Hyalonema, Fig. 1, which we have taken from Dr. Thompson's book, and then let us attempt a description.

Suppose we should take a skein of smooth, compactly-spun, glossy white silk, about twenty-four inches in length, and, cutting the ends off evenly at one extremity, should give it a loose twist along the entire length, except some six inches at the bottom, which we leave, so to speak, frayed, or shaken out. Then around the other end of this silken cord or coil we affix a cup-like tuft of buff-colored zephyr worsted-work, having the end of the skein projecting a little higher than the rim, and covered with the same material. Now, from just below the base of the cup-like tuft, let us encase the white coil tightly down to where its threads fray out; let this cylindrical case be of a dark-brown color, and leathery aspect, and ornamented with little starry knobs or warts, like raised embroidery—and then, so far as form is concerned, you have the Hyalonema, or glass-sponge of Japan.

It thus appears from the above that the structure has three parts—the buff-colored mass at one end, the long shaft of white threads, and the star-embossed case which envelops the axis or shaft. Now, what

FIG. 2.



White. Red. White.

JAPANESE DRAWINGS OF HYALONEMA SIEBOLDI. (The artist, not knowing the facts in the case, has figured them in wrong position. Compare with Figure 1.)

is the material nature of each part? There is no difficulty about the buff-colored mass, in form like a cup. It has the spicules, and the sarcode, which characterize the sponge-flesh. The axis or coil is of pure translucent silex, like white threads of glass. The surrounding sheath, with the starry prominences, is of a horny or keratose material, much like the stems of the sea-fans, and it is a curious fact that

this horn-like sheath is coated with a fine silicious powder, just as it would look if made of India-rubber, and while in the soft, adhesive condition dusted over with fine sand. With so much told, we are prepared for the curious scientific history of this interesting object, which bears a number of popular names, such as Glass-Plant, Glass-Coral, Glass-Rope, etc.

When the scientific men of Europe first made acquaintance with it, this object was an enigma, and for years the subject of much learned controversy. In 1835, some specimens, brought by the traveller Von Siebold, received special study by Dr. John E. Gray, of the British Museum, who named the object *Hyalonema Sieboldi*. On one point, to use a legal phrase, "each and every" of these learned men literally lost his head when studying this apparent abnormal nondescript; for they all alike stood the specimens on their heads, that is, they placed them, for study, theoretically upside down, namely, with the conical sponge heads, or masses, downward, and of course the coils of silica standing up. It must have been that the Japs themselves started this notion, in honest ignorance, as I believe; for in some natural-history engravings, done by native artists, which are now before me, these objects are portrayed, with the thread-like ends upward, and the sponge mass downward, and as if adhering to something (Fig. 2). This is curious, as the Japanese exhibit in their drawings a closeness in the observation of details that is almost scientific.[1] Dr. Gray's position made the sponge to grow on some object, or on the bed of the sea, and out of the sponge-mass so adhering, like a glass brush standing on its

[1] I am indebted to our Japanese students at New Brunswick for an explanation of the words on Fig. 2. They are the popular names of these objects in Japan. The cut gives three representations of Hyalonema, the Japanese Glass-Rope Sponge. The middle one of them in the original has the fascicles, or bundles of silicious threads, colored red, while the others are white. They are also represented as growing crowded together, some six or more in a group. The Conical Sponge masses, too, are flattened, as if they were adhering at the base to a rock. The fascicles, too, are naked, like the specimens that Japanese ingenuity has prepared for market; that is, they are devoid of any encrusting polyp case or bark. It is evident that the artist has drawn upon the popular understanding of the subject, and his own inner consciousness. The one with the red fascicles, the color being probably the outcome of a lively imagination, has the Japanese name *Aka-hossz*. The word *hossz* means a brush of long white hair, such as is used by the Buddhist priests, and is derived from the adjective *hosoi*, meaning fine, thin, delicate. *Aka* means red. The others, which have the usual white fascicles, are named *hoshi-kai*. The words *hoshi* and *hossz* seem to be interchangeable, as they are identically the same, but are changed in the spelling for some reason not apparent. *Hoshi*, then, means a brush of long white hair, and *kai* means a small bivalve. The word has that general application to mollusks and crustaceans which seems to carry with it the significance of our popular word shell-fish. The common name, then, of the Glass-Rope Sponge, in Japan, would seem to be *the Shell-fish with the brush of white hair*, or *the Long-white-haired Shell-fish*; and, as we have the anomalous expression, a white-blackbird, so the Japanese have the *Red White-haired Shell-fish*. Of course, no claim is here set up for philological accuracy, although the above is believed to be sufficiently correct for the purpose in hand.

S. L.

handle, and spreading out in the water, grew the zoophyte, as he regarded the silicious whisp, and its bark-like envelop. Now, among the polyps, known as Alcyonarians, is the Gorgonia, or Sea-fan, which has an axis of a horn-like nature, and a crust of lime; so he made of this polyp, which he supposed constructed the axis and the case, an Alcyonarian, allied to those polyps which build the Sea-fans. But the difficulty was that, instead of a centre or core of keratose, with an

FIG. 3.

EUPLECTELLA SPECIOSA. THE VENUS FLOWER-BASKET: A Glass Sponge. That on the right is a portion of the natural size, intended to show the lace-like meshes. The full figure is about half the natural size.

envelop of lime, this had a core or axis of silica, and a bark of keratose. According to Dr. Gray, the Hyalonema was really two animals, namely, the polyp, represented by the glass coil, and its horny crust; and the sponge, represented by the conical spicular mass, which as a new species he named *Carteria*.

Prof. Milne-Edwards, in 1857, described the sponge-mass and the glass-rope as but one animal, and "degraded the zoophyte to the rank of an incrusting parasite."

In 1859 appeared the magnificent work of Dr. Brandt, of St. Petersburg, on the Hyalonema. Now, the tables are completely turned. The silicious rope, and its warty bark, are declared to be parts of a polyp, and the sponge is announced as the parasite!—"attaching itself to the polyp, gradually penetrating its silicious axis, and finally killing it." Poor, innocent sponge! Even at the risk of being unparliamentary, we rise to brand that statement as a libel on the sponge.

In 1860 appeared the elaborate memoir on the Hyalonema by Prof. Max Schultze, of Bonn. He describes the glass-coil and the sponge-mass as belonging to one and the same animal structure. The warty crust, or case, he refers to a distinct animal, a polyp to which he gives the name *Palythoa fatua*. Schultze, however, makes the polyp a "commensal" with the sponge; that is, they both live at the same table, which means that the sponge, by its ciliary action, has to supply food for both. Schultze's exposition is the generally accepted one. His idea of commensalism, however, the present writer cannot accept. Nor can he accept Milne-Edward's degradation of the zoophyte to a parasite. But want of room will not permit a statement here of the reasons of his disbelief.

The curious fact made clear is that, through all these years of earnest investigation, Hyalonema was studied upside-down, until Prof. Lovén published his ingenious paper (in 1867, we think), in which, by a little stalked pyriform deep-sea sponge, he demonstrated the true position or attitude in life of the Hyalonema. In 1870 Prof. Joseph Leidy attained the same conviction from a different line of argument. It was pretty much as if one should ask, "Should a house stand on its chimney?" Says Dr. Leidy: "It has occurred to me that the sponge-mass, in its natural position, was uppermost, and was moored by its glassy cable to the sea-bottom; this opinion is founded on the circumstance that in sponges generally the large oscules from which flow the currents of effete water are uppermost." In fact, these glassy threads, at their lower extremities, spread out in a spiral manner, much like the spray from a turbine water-wheel, and, thus penetrating the mud, afford a good anchorage. This mooring is greatly helped, too, by the peculiar structure of these long silicious needles. These needles, or glassy threads, are, in the body of the fascicle, or skein, cylindrical, and smooth; but, toward their extremities, they are

rugose, having almost imbricating rings. Beheld for the first time under the microscope, its sight recalled the appearance of the hairs of a bat. I have convinced myself that this is the functional intention of the frayed end of the fascicle, by a careful examination of a suite of specimens obtained for me at Enosima, Japan, by Prof. Griffis, of the Imperial College at Yeddo.

But the deep-sea dredging described in Dr. Thompson's book sheds much light on the Hyalonema. Says the writer: "When we trace its development, the coil loses its mystery. In two or three hauls we got them in every subsequent stage—beautiful little pear-shaped things, a centimetre long, with a single osculum at the top, and the whisp like a small brush. At this stage the *Palythoa* is usually absent, but, when the body of the sponge has attained 15 mm. or so in length, very generally a little pink tubercle may be detected at the point of junction between the sponge-body and the coil, the germ of the first polyp."

FIG. 4.

PHERONEMA ANNÆ. Half the natural size. A glass-sponge, obtained at Santa Cruz, W. I.

Allusion has been made to the ingenious manipulation of these glass-sponges by the Japanese. Says Dr. Hadlow, then in Japan: "We sometimes meet with portions of the glass coil most ingeniously attached to and grouped with corals, shells, and other ma-

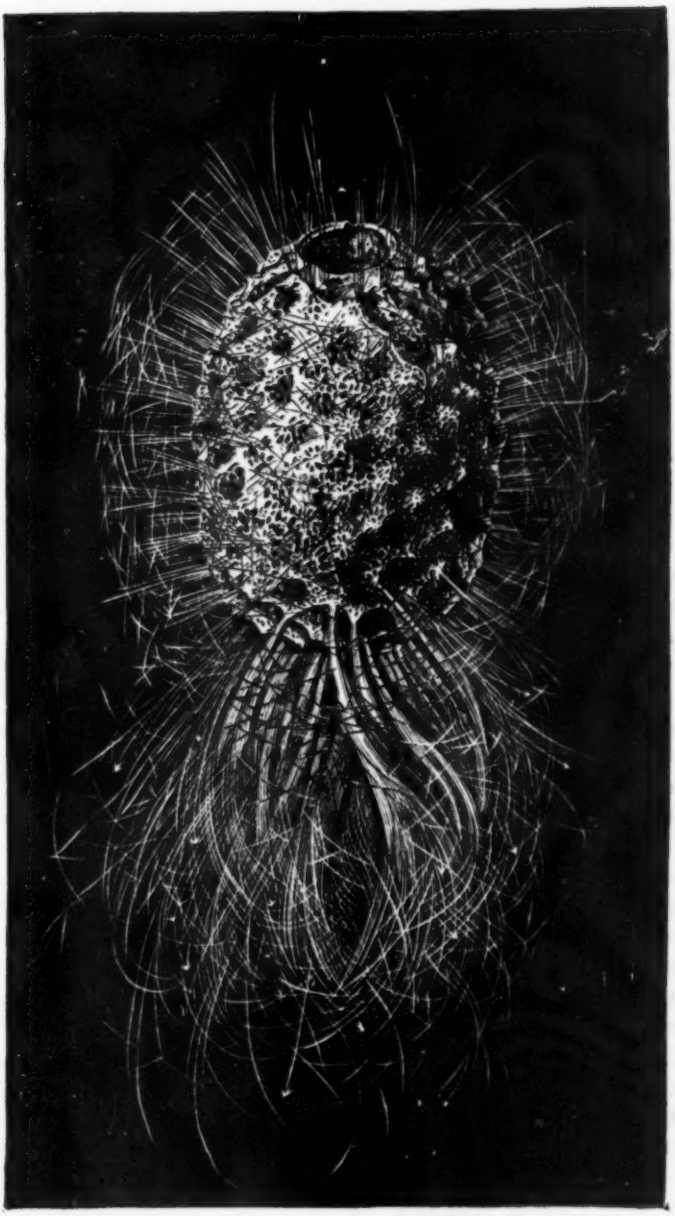
rine products. . . . Such arrangements are entirely artificial, notwithstanding that they are often so artistically done as to have a most deceptively natural appearance."[1] The prettiest specimen of Hyalonema the writer ever saw, one worthy to be called *unique*, was a clever put-up job. Even to a part of the polyp encasement, from one end to the other, it was put together much as we have seen some fraudulent bird-stuffers put into the tail, wings, and even the crown of the head, feathers from other birds.

Hyalonema was the first of the glass-sponges known to science. It came among the *savants* as an anomaly of animal structure. Soon after appeared the Venus's Flower-Basket, the peerless beauty among the glass-sponges. In two remarkable respects it resembled its predecessor. Like Hyalonema, it was moored to the sea-bottom by glassy threads; and, like the pretty Glass-Rope Sponge, it made its *début* in scientific society standing on its head! It was actually so figured by Dr. Owen, its original describer, in the "Zoological Transactions of London." The name by which it is now known is well deserved by an object so lovely—*Euplectella speciosa*. The first of these words means well-woven, while the second intensifies the first, so that the meaning really is, the specially beautiful, well-woven (Fig. 3.)

It is almost hopeless to attempt a description of Euplectella in words. Nor has any artist yet done justice with his pencil to the delicate fabric. The first specimen that reached England, and which for a long time was the only one known, was purchased by William J. Broderip, for the sum of $150 in gold. Says Prof. Owen: "Mr. Cuming has intrusted to me for description one of the most singular and beautiful, as well as the rarest of the marine productions." Euplectella is in form a cornucopia, at the lower end about an inch in diameter, and in good specimens, after making a graceful curve, terminating at top in a width of nearly two inches. This part has a cover with a frilled edge, which, in a complete specimen, projects about a fourth of an inch over the sides. The bottom, or smaller end, is encompassed with a dense ruff of glass threads, so delicately white, flexible, and fine, that they look like a tuft of floss-silk. This muff-like surrounding is sunk into the deep-sea ooze, the fibres pointing up, which, though effectual, is certainly an odd way of mooring itself. In this manner this sponge is, when living, in a perpetual bath of mud. Like Hyalonema, our Euplectella is an anchoring sponge. Venus's Flower-Basket looks like a structure made of spun-glass; and so fragile that one hesitates to take it into the hands. It is wonderfully light—reminding, in this respect, of the skeleton or phantom flowers sometimes seen under glass. But Euplectella, although really so delicate, is quite strong. The threads which make up this fabric of woven

[1] "The Hyalonema Mirabilis." Read, October 30, 1872, before the Asiatic Society of Japan, by Henry Hadlow, Surgeon R. N. Printed in the *Japan Weekly Mail*, March 1, 1873.

FIG. 5.



ROSSELLA VELATA, natural size. A glass-sponge dredged off the Strait of Gibraltar in 651 fathoms.

glass are so flexible that a body is led to wonder if this is like the product of that lost art. To us it seems doubtful whether any woven glass, the product of art, can quite affect the singular lustre that belongs to these silicious threads spun from Nature's distaff. Each thread, although of pure silica, and solid, is really composed of a series of concentric tubes or cylinders, as if spun on a central thread or core. The effect, as respects the light, is not easily described. As the threads are composed of pure silica, one might suppose that they would be transparent, as a film of pure white glass of equal thickness. Such is not the fact. They are translucent, and have just an appreciable tint of the opal. It is this that imparts to Euplectella that softness of aspect which has been called "a delicate satiny lustre." To us the term opalescent seems better. We have a specimen which, in a good light, shows the play of colors that frozen crispy snow does in the moonlight.

As to the idea "well-woven," which the name contains, the fabric really seems to have its web and its woof. There are long threads that traverse the whole length; and there are others that cross and interlace, or, more correctly, interweave. And, what no loom of human invention has ever done, this lowly weaver makes the fabric as it progresses take on the most quaintly little flounces with the most delicate frilled edges imaginable; and all arranged in such charming grace and ease—not in parallel circles, like hoops on a barrel, but in tasteful, easy-flowing curves. In the configuration of the innumerable forms of structure, Nature, as she ascends in the grade of her work, almost abandons her parallels in the outlining and ornamentation of her constituted things. In the mineral province the structure of crystals shows her delight in parallel, straight lines. The curve is a rarity there. But in organic forms the curve is the rule, and the straight line is the exception. The lace-like structure of the Euplectella is so aërial a fabric, and so quaintly graceful, and, as one might say, so deftly done in the putting together, that any embroidery would seem in the comparison bungling. Enflounced in its own tiny, crispy frills, there is an air of improvised beauty. And there is a flavor of rank in the almost grotesque hint thrown out by the sometimes queer sort of relief afforded in this excess of elegance by a dash of chevron-work.

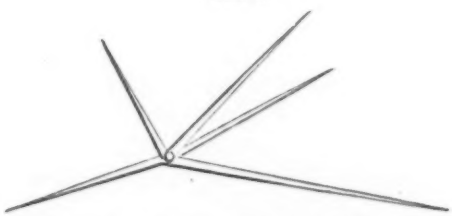
Euplectella is chiefly got from the Philippine Islands. The natives have their own notions, it seems, about this marvellous object. They will tell you that this beautiful sponge is found in pairs, and that they are the work of little crabs, who, they believe, build these houses while living inside them. It is a remarkable fact that generally in these glass cornucopias, as if they were cages, a pair of little crabs dwell together. How they ever got inside nobody knows. Can it be that they are silly enough to wall themselves up in this limbo of silica? Not they, although they do have nippers and thumbs. A

much lowlier creature, fingerless, and for that matter organless, uprears these fairy structures. However, the fact is indisputable. There they are, incased in glass, and beyond the possibility of deliverance. Were these little folks communicative, and not so crabbed, one might ask if they acted out the moral of the adage about people who live in glass houses. There is little doubt that this imprisonment is voluntary. We think these crabs are true commensals. Whether welcome or not, they always eat at the Euplectella's table. Lest we should seem to be muddling the work of the systematists, we would be understood metaphorically, when stating our positive conviction that these crabs are sponges from their very birth.

A new glass-sponge, obtained from the island of Santa Cruz, W. I., is described by Prof. Joseph Leidy, in the *American Naturalist* for March, 1870. Some description of it had already been given elsewhere. Its form is seen in Fig. 4. It will be remembered that the glass-rope sponge had one fascicle or bundle of glass threads. This sponge has at least twenty of these bundles, each about two inches long. These also are of silicious threads, and have the appearance of "tufts of blond human hair." It would not be strange should a lady naturalist liken them to skeins of *cuir*-color zephyr worsted; for, queer as this may seem, such would be an unconscious guessing of the name which this new sponge has received. Pheronema means the *skein-bearer*. "In honor of his wife," Prof. Leidy "has dedicated the species under the name of *Pheronema Annæ*.

The names of this trio of wonderful sponges are, it will be seen, expressive, euphonious, and picturesque — Hyalonema, the glass, or hyalene skein — Euplectella, the accomplished weaver — Pheronema, the skein-bearer.

Fig. 6.



A Group of United Spicules in Pheronema.

And now, like wresting jewels from the land of Ind, the naturalist has found that these inimitable gems are of many kinds and abundant, but locked up in the hitherto unapproachable coffers of the deep sea. First, the Norwegian scientist invaded this domain, and bore off amazing treasures. Then the Americans tried these great depths, and brought up gems that amazed the eyes of the naturalist. Then came the English expeditions, tolling the ocean treasury at the astounding depth of 15,000 feet! It is now found that the congenial home

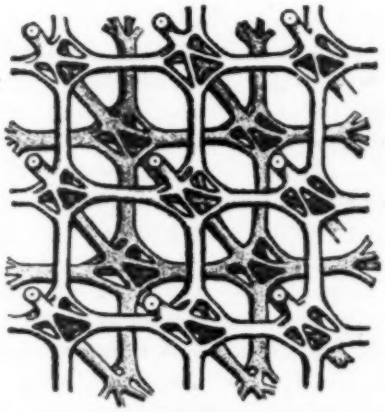
of the glass-sponges is the emphatically deep water. There are precious stores of exquisite forms and structures, that have never been seen by any except their Creator. One of these, described in Dr. Thompson's book, which was obtained during the cruise of the Lightning, is named in honor of M. Holten, the Danish governor at Faroe, and Prof. Carpenter—hence the appellation *Holtenia Carpenteri*. It is about nine inches long, and three and a half inches wide. The body of this glass-sponge is of an oval, or egg-shaped form. At the bottom is a great mass of fine silicious threads, like white hairs, wadded together like a mop. These are its anchoring threads. There is a crater, or oscular opening at top, about three-fourths of an inch wide, around which, on the outside, short threads of silica stand out, not unlike a beard. Thus the upper part of the sponge might be likened to a bird's-nest. Hence the Setubal deep-sea shark-fishers, who sometimes bring them up from great depths with threads of Hyalonema on their fishing-lines, call them "sea-nests." The spicules are arranged in little stellate groups, the effect being that the entire surface of the sponge has an ornamentation of stars.

We can mention but one more of these singular beings. This is the *Rossella velata*, Fig. 5. And here we will borrow Dr. Thompson's own words: "On August 30, 1870, Mr. Gwyn Jeffreys dredged in 651 fathoms in the Atlantic off the mouth of the strait of Gibraltar an exquisite sponge, resembling *Holtenia* in its general appearance, but differing from it in the singular and beautiful character of having a delicate outer veil, about a centimetre from the surface of the sponge, formed by the interlacing of the four secondary rays of large five-rayed spicules, which send their long shafts from that point vertically into the sponge-body. The surface of the sponge is formed of a network of large five-radiate spicules, arranged very much as in *Holtenia;* but the spicules of the sarcode—the small spicules which are embedded in the living sponge-jelly—are of totally different form. A single large 'osculum' opens, as in *Holtenia*, at the top of the sponge, but instead of forming a cup uniformly lined with a netted membrane, the oscular cavity divides at the bottom into a number of branching passages, as in *Pheronema Annæ*, described by Dr. Leidy. The spicules of the 'beard' are more rigid and thicker than those of *Holtenia*, and scattered among them are some very large four-barbed grappling-hooks." Such is the capital description of the learned naturalist. To be sure, some old "salt" would be more laconic; for he doubtless would tell you that it was like a pine-apple, with the crown and its core removed.

We have tried to make plain what is meant by sponge-flesh, for which the word sarcode is used. It should be understood that this sarcode, which is a semi-fluid substance, is simply held to the mesh-like skeleton and to itself by the interlacing of tiny needles of flint, called spicules, so that the albuminous-like flesh is really felted to-

gether. From the sponge of the toilet this sarcode and its spicules have been all removed. The interesting fact is that, while these spicules are arranged in different patterns, many being made to radiate like stars, no two species have the same pattern. Look at Fig. 6, which represents the spicules of *Pheronema*. It looks as if

FIG. 7.



SECTION OF THE OUTER WALL OF VENTRICULITES SIMPLEX, showing the structure of the silicious net-work. Magnified 50 times.

the series were united together to make an irregular star. Now, one of these needles sticks perpendicularly into the sarcode, leaving the other rays to spread out in a plane, to which the one that serves as a spike is perpendicular. One might liken it to a parasol without its silk covering—the handle in the hand is the spike, and the steel ribs

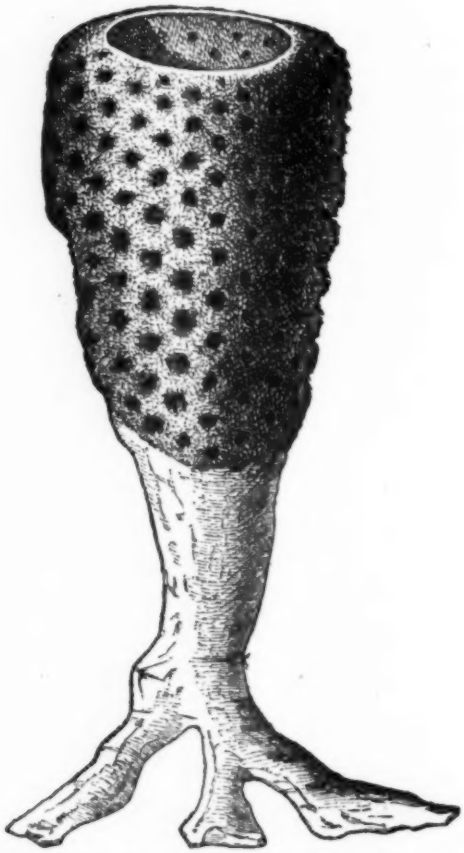
FIG. 8.

EXTREMITY OF A MOORING-THREAD OF PHERONEMA, showing the notched sides and the anchor-flukes at the end. Greatly magnified.

spread out will represent the silicious rays, or spicules. At a little distance from this penetrating needle, or spike, the needle of another of these irregular stars pierces the sarcode. Of consequence, the radiating needles, or spicules, of each one of these irregular stars lock into the similar spicules of the adjoining star, and so on for the entire mass, until it has the effect of felt; with this great difference, however—so regular is this natural felting of the sponge-flesh—that the whole mass is spiculated or laid out in quite regular and pretty patterns; and such is the uniformity of pattern for each kind that they actually

mark the difference of species. As evidence of this regularity and beauty, look at the engraving of the spicular pattern of a fossil glass-sponge (Fig. 7). Now, it should be observed of the sponges which we have given in detail, that their spicules are arranged on a six-rayed plan, or, as sometimes expressed, hexradiate. Accordingly, Prof. Oscar Schmidt has "defined the group as a family under the name *Hexactinellidæ*."

FIG. 9.



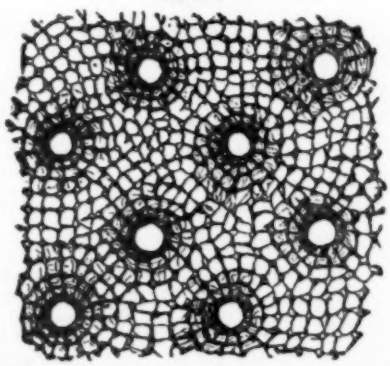
VENTRICULITES SIMPLEX.—A fossil sponge, once and a half the natural size, showing the surface ornamented by a regular arrangement of ventricles. (*See* Fig. 10.)

Many of these glass-sponges have the habit of mooring themselves by their silicious threads, and on this account are called "anchoring sponges." Though acting in this matter on one general principle, yet they have diversities of ways in carrying out this law of their nature. *Hyalonema*, the glass-rope sponge, plunges its long threads down into the mud, and then spreads them out like a brush. These threads have a ringed structure, so that each one has an individual hold, or

purchase, like that of a screw. Venus's Flower-Basket has the small end of the cornucopia plunged deeply into the sea-ooze, and from its extreme end threads go out with an upward and outward curve. Thus the mud rests upon them on the inside of the curves, and holds the dish-shaped tuft of fibres down. *Pheronema* has its threads near the extremities marked by projecting notches, while at the very extremity it is actually anchor-shaped, as shown by a thread magnified (Fig. 8). *Holtenia* has a great mop of fine roots, like what is often seen when changing a plant from one flower-pot to another. *Rossella* has a great outlay of mooring-threads, with frequently a line quadrate-barbed at its extremity. This is well shown in Fig. 5. These lines have actually at the bottom a four-hooked grapnel.

A very interesting fact is this: The study of these *Hexactinellidæ* has made clear as light the structure and character of the curious flinty fossils obtained from the cretaceous formation, and known as *Ventriculites*. Fig. 9 shows one of these fossils, and Fig. 10 shows its beautiful spicular structure. It is now plain that they were glass-sponges, and also belonged to the family *Hexactinellidæ;* while the deep-sea dredging, as it brings up these so-long-concealed witnesses, is proving that our notion, that the cretacean forms of life belonged wholly to the great past, needs careful revision; for it may be that this ante-biotic theory is not quite correct.

FIG. 10.



OUTER SURFACE OF THE FOSSIL SPONGE, VENTRICULITES SIMPLEX, magnified four times, showing the ventricles which make the outer ornament. (*See* Fig. 9.)

And there are many strange and also beautiful forms of life that are the companions of these deep-sea sponges. Yes, and even almost formless conditions of life are there. A substance like albumen, a sort of protoplasm, spreads over the broad acres of the sea-bottom. Perhaps it is the manna which Providence has given to these wonderful creatures that occupy these deserts beneath the sea. Certain it is that, in two senses, the dredger is plunging into the profoundest physical problems. How precious, then, is every grain of mud obtained from

such depths! Hence the careful treatment it receives when brought on deck. Fig. 11 shows the sieves used. The whole nest of four is used at once. Some of the mud is put into the top one, which has large meshes, these meshes decreasing in size, so that the smallest are in the sieve at the bottom. The whole are set in a deep tub of sea-water. There is to be no turning round of the sieves, as that would break or bruise some of the frail organisms. Taking hold of the handles of the bottom sieve, the whole nest is lifted up and down with a gentle churning motion; and, when the mud is all passed through, the objects are tenderly removed to jars of sea-water. A bone forceps is used for this purpose.

FIG. 11.

THE SIEVES USED IN SEPARATING THE CONTENTS OF THE DREDGE IN DEEP-SEA DREDGING.

What a wonderful, yea, fascinating thing, then, is this lovely glass-sponge! It is amazing that a creature so simple, that it has been called structureless, should surpass all other organisms in its capacity of rearing exquisite fabrics. And, now that we have had time to sober down a little in our raptures over its structural beauty, and, so to speak—like one that has passed from the pleasant contemplations of art to the graver meditations of philosophy—to listen with composure to its deeper teaching, we find it casting new light upon the inquiries of Science—even lifting a corner of the veil of the covered past. So little, until lately, did we know about the glass-sponge, that we were like the purblind prehistoric man working patiently at his flint nodule to fashion it into an implement for use, little dreaming that some glass-sponge had been the ancient eliminator and conservator of the solvent silex of the sea, and had, through subsequent geologic action, preserved its skeleton for the service of that ruder artisan. What a freight of precious knowledge will that be, when the good ship Challenger shall have returned from her four years' dredging around the world, among that newly-opened "Abyssal Fauna," whose province covers 140,000,000 square miles beneath the blue mantle of "the myriad smiling sea!"

THE CONSTITUTION OF MATTER.

By FERNAND PAPILLON.

TRANSLATED BY A. R. MACDONOUGH.

WHATEVER empirics and utilitarians may say of them, there are certainties apart from the experimental method, and there is progress disconnected with brilliant or beneficent applications. The mind of man may put forth its power in laboring in harmony with reason, yet discover genuine truths in a sphere as far above that of laboratories and manufactures as their sphere is above the region of the coarsest arts. In a word, there is a temple of light that unfolds its portals to the soul neither through calculation nor through experiment, which the soul nevertheless enters with authority and confidence, so long as it holds the consciousness of its sovereign prerogatives. When will professed scientists, better informed of the close connection between metaphysics and science, whence our modern knowledge of Nature has sprung, better taught in the necessary laws that govern the conflict of reason with the vast unknown, confess that there are realities beyond those they attain? When will science, instead of the arrogant indifference it assumes in presence of philosophy, admit the fertility beyond estimate of the latter? It may be that the hour of this reconciliation, so much to be longed for, is less remote than many suppose; at least, every day brings us nearer to it. The spirit of Descartes cannot fail to arouse before long some genius mighty enough to revive among us a taste and respect for thought in all the departments of scientific activity. Deserted as high abstractions are for the moment, they are not, thank Heaven, so utterly abandoned as to deprive study of its ardor, and essays of their success, when these relate to the problem of the constitution of matter. In fact, this is a question which for several years past has occupied some among our own *savants* and thinkers, as completely as it has employed most of those of the rest of Europe, a question which bears witness with peculiar eloquence to this fact, that, if philosophers are forced to borrow largely from science, in its turn science can retain clearness, and elevation, and strength, only by drawing its inspiration from, and recognizing its inseparable connection with, the abstract consideration of hidden causes and of first principles.

I.

Matter is presented under a great variety of appearances. Let us consider it in its most complicated state, in the human body, for instance. In this, ordinary dissection distinguishes organs, which may be resolved into tissues. The disintegration of the latter yields ana-

tomical elements from which direct analysis extracts a certain number of chemical principles. Here the anatomist's work ends. The chemist steps in, and recognizes in these principles definite kinds arising from the combination, in fixed and determinate proportions, of a certain number of principles that cannot be decomposed, substantially indestructible, to which he gives the name of simple bodies. Carbon, nitrogen, oxygen, hydrogen, sulphur, phosphorus, calcium, iron, which thus set a limit to experimental analysis of the most complex bodies, are simple substances, that is to say, they are the original and irresolvable radicals of the tissue of things.

We now know that matter is not indefinitely divisible, and that the smallest parts of the various simple substances existing in those that are naturally compound have not all the same dimensions, nor equal weights. Chemistry, by a course of analyses and measurements, has succeeded in determining the weights of atoms of the different elements, that is to say, taking as a unit an atom of the lightest element, hydrogen, in determining the weight of the atoms which are equivalent to this conventional unit in the various combinations. Though many *savants* continue to maintain that atomic weights are nothing but relations, and that the existence of atoms is a mere logical device, it seems more reasonable to admit, with the majority of those who have studied this difficult problem closely, that these atoms are actual realities, while it may be very far from easy to settle precisely their absolute dimensions. In any case, we may affirm that these dimensions are very much less than those presented by the particles of matter subjected to the most powerful and subtle methods of division, or decomposed by the imagination into its minutest elements. "Let man," says Pascal, "investigate the smallest things of all he knows; let this dot of an insect, for instance, exhibit to him in its diminutive body parts incomparably more diminutive, jointed limbs, veins in those limbs, blood in those veins, in that blood humors, and drops within those humors—let him, still subdividing these finest points, exhaust his power of conception, and let the minutest object his fancy can shape be that one of which we are now speaking—he may, perhaps, suppose that to be the extreme of minuteness in Nature. I will make him discover yet a new abyss within it. I will draw for him not merely the visible universe, but all besides that his imagination can grasp, the immensity of Nature, within the confines of that imperceptible atom." In this Pascal displays a feeling as true as it is deep of the infinitely small, and it is interesting to observe how the amazing revelations of the microscopic world have justified his eloquence and foresight; and yet this microscopic world, whose minutest representatives, such as vibrios and bacteria, are hardly less than the ten-thousandth part of $\frac{1}{25}$ of an inch, how coarse it is compared with the particles thrown off by odorous bodies, and with the inconceivably minute quantities which chemistry, physics, and

mechanics, now measure without seeing them, or make their existence plain without grasping them! We may mention some instances which can give us an idea of these.

According to Tyndall, when very minute solid particles, smaller than the luminous waves, are diffused in a medium traversed by light, the light is decomposed in such a way that the least waves, the blue ones, predominate in the reflected rays, and the largest ones, the red waves, in the transmitted rays. This ingenious physicist thus explains how the blue color of the sky depends and must depend on the existence of solid particles, excessively minute, diffused in infinite quantity through the atmosphere. Tyndall is not disinclined to the idea that these imperceptible atoms might very well be no other than those germs of microscopic organisms the presence of which in the atmosphere has been proved by the labors of Pasteur, as well as the part they take in the phenomena of putrefaction and fermentation. The ova of these beings, which are barely visible under the microscope after attaining full development, and of which the number, ascertained by the most decisive evidence, confounds the boldest imagination, these would be the elements of that vital ether, as we have termed it, that dust which gives its lovely blue tint to the vault of the sky. "There exist in the atmosphere," Tyndall says in closing, "particles of matter that elude the microscope and the scales, which do not disturb its clearness, and yet are present in it in so immense a multitude that the Hebrew hyperbole of the number of grains of sand on the sea-shore becomes comparatively unmeaning." And to give an idea of the minuteness of these particles, Tyndall adds that they might be condensed till they would all go into a lady's travelling-bag. Manifestly these particles escape any kind of direct measurement and observation. Their objective reality can no more be demonstrated than that of the particles of ether can be made evident. Yet there are certain facts which aid us to form a clear conception of them. Let us dissolve a gramme of resin in a hundred times its weight of alcohol, then pour the clear solution into a large flask full of pure water, and shake it briskly. The resin is precipitated in the form of an impalpable and invisible powder, which does not perceptibly cloud the fluid. If, now, we place a black surface behind the flask, and let the light strike it either from above or in front, the liquid appears sky-blue. Yet, if this mixture of water and alcohol filled with resinous dust is examined with the strongest microscope, nothing is seen. The size of the grains of this dust is much less than the ten-thousandth part of $\frac{1}{25}$ of an inch. Moren makes another experiment, proving in a still more surprising way the extreme divisibility of matter: Sulphur and oxygen form a close combination, called by chemists sulphuric-acid gas. It is that colorless and suffocating vapor thrown off when a sulphur-match is burned. Moren confines a certain quantity of this gas in a receiver, places the whole in a dark medium, and sends a bright ray of light

through it. At first nothing is visible. But very soon in the path of the luminous ray we perceive a delicate blue color. It is because the gas is decomposed by the luminous waves, and the invisible particles of sulphur set free decompose the light in turn. The blue of the vapor deepens, then it turns whitish, and at last a white cloud is produced. The particles composing this cloud are still each by itself invisible, even under strong microscopes, and yet they are infinitely more coarse than the primitive atoms that occasioned the sky-blue tint at first seen in the receiver. In this experiment we pass in steady progress from the free atom of sulphur parted from the oxygen-atom by the ether-waves to a mass apparent to the senses; but, if this mass is made up of free molecules which defy the strongest magnifiers, what must be the particles which have produced those very molecules!

A last instance of another kind will complete the proof as to the minuteness of the elements of matter. When a clear solution of sulphate of aluminum is poured into an equally clear solution of sulphate of potassa, the mixture at once grows turbid, and after a few seconds myriads of little crystals, sparkling like diamonds, make their appearance in the liquid, which are nothing else than crystals of alum. If we suppose the diameter of these crystals to be $\frac{1}{25}$ of an inch, it will follow from this experiment that in the lapse of a few seconds crystals had the power of producing themselves containing tens of millions of molecules, each composed of 94 atoms, grouped in admirable harmony. The motions of these chemical atoms take place under the influence of the same forces that guide the motions of those enormous agglomerations of atoms called stars. The revolution of one sun around another takes a thousand years, while these atoms in course of combination perform hundreds of millions of such revolutions in the millionth part of a second!

By varied and delicate calculations, Thomson has succeeded in establishing the fact that, in liquids and transparent or translucent solids, the mean distance between the centres of two contiguous atoms is comprised between the ten-millionth and the two-hundred-millionth part of $\frac{1}{25}$ of an inch. It is not easy to form an exact conception of dimensions so small, of which nothing, among the objects that affect our senses, can convey any idea. Thomson judges that the following comparison may aid us to appreciate them: If we imagine a sphere as large as a pea magnified, so as almost to equal the earth's volume, and the atoms of that sphere enlarged in the same proportion, they will then have a diameter greater than that of a shot, and less than that of an orange. In other words, an atom is to a globe the size of a pea what an apple is to the terrestrial globe. By arguments of quite another kind, drawn in part from the study of chemical molecules, in part from the phenomena of capillarity, Gaudin has ascertained, for the dimension of the smallest particles of matter, figures very nearly the same as Thomson's. The maximum distance apart of the chemical

atoms in molecules is the ten-millionth part of $\frac{1}{25}$ of an inch. Gaudin follows Thomson in the attempt to give some sensible notion of the truly amazing minuteness of a dimension like this. He calculates, upon this estimate, the number of chemical atoms contained in about the size of a pin's-head, and he finds that the number requires for its expression the figure 8 followed by twenty-one ciphers. So that, if we attempted to count the number of metallic atoms contained in a large pin's-head, separating each second ten millions of them, we should need to continue the operation for more than 250,000 years!

There are, then, atoms in matter, and atomism is a fact, whenever we rest in the affirmation of the existence of atoms. But these are not the real principles, the simple and irreducible elements of the world. After decomposing sensible matter into atoms, we must subject the latter to an analysis of the same kind. Let us, then, consider any two heterogeneous atoms whatever, an atom of iron and an atom of hydrogen, for instance, and examine in what respect they can really, essentially, differ from each other. What is it which at bottom truly distinguishes these two atoms, as atoms? It is not any peculiarity of form, solidity, fluidity, hardness, sonorousness, brightness, because these properties evidently depend on the mutual arrangement and disposition of atoms, that is, because they are not relative to the individuality of each atom, but to that of the whole which they form by being grouped together. Neither is it any caloric property, or optic, or electric, or magnetic one, because these properties result from the movements of the ether, within the more or less complex aggregate of the respective atoms of these two substances. Now, if these atoms, taken separately, differ from each other in virtue of none of the properties just enumerated, they can only be dissimilar as regards two attributes, dimension and weight; but difference in weight results from difference in dimension, and is not a qualitative difference, but simply a quantitative one. Consequently, any two heterogeneous atoms whatever, compared together, as atoms, have scarcely any of the differential attributes peculiar to the groups which they make up by aggregation, and represent no more than two distinct functions, two different values of one and the same initial matter, of one and the same primitive quality or energy. This simple demonstration establishes the unity of substance, not as a more or less plausible physical hypothesis, but as a metaphysical certainty, alike underivable and necessary. If we add now, reserving the demonstration for a later period, that dimension, corporeal extension itself, as Leibnitz said and as Magy has lately proved, is only a resultant of force, it will become evident that matter, in the last analysis, is reduced to force.

Tyndall, in his biography of Faraday, tells us that one of the favorite experiments of this physicist gives a true image of what he was: "He loved to show how water, in crystallizing, eliminates all foreign substances, however intimately mingled they may be with it.

Separated from all these impurities, the crystal becomes clear and limpid." This experiment is especially the true image of what Faraday was as a metaphysician. For him nothing had so great a charm as those serene transparent regions, in which science, cleared of impurities, appeared to his great mind in all the glory of its power and splendor. He yielded himself to it with absolute abandonment. He particularly loved to dwell upon the problem which is now engaging us: "What do we know of an atom apart from force?" he exclaims. "You conceive a nucleus which may be called *a*, and you surround it with forces which may be called *m*; to my mind your *a* or nucleus vanishes, and substance consists in the energy of *m*. In fact, what notion *can* we form of a nucleus independent of its energy?" As he holds, matter fills all space, and gravitation is nothing else than one of the essentially constitutive forces of matter, perhaps even the only one. An eminent chemist, Henry Saint-Claire Deville, lately declared that, when bodies deemed to be simple combine with one another, they vanish, they are individually annihilated. For instance, he maintains that in sulphate of copper there is neither sulphur, nor oxygen, nor copper. Sulphur, oxygen, and copper, are composed, each of them, by a distinct system of definite vibrations of one energy, one single substance. The compound, sulphate of copper, answers to a different system, in which the motions are confounded that would produce the respective individualities of its elements, sulphur, oxygen, and copper. Moreover, Berthelot long ago expressed himself in exactly the same manner. As long ago as 1864 that *savant* said that the atoms of simple bodies might be composed of one and the same matter, distinguished only by the nature of the motions set up in it. This decisive saying a great number of *savants* and philosophers in France and abroad have repeated and are still repeating, with good reason, as the expression of a solid truth.

If the smallest parts which we can imagine and distinguish in bodies differ from each other only by the nature of the motions to which they are subjected, if motion alone rules and determines the variety of different attributes which characterizes these atoms, if in a word the unity of matter exists—and it must exist—what is this fundamental and primary matter whence all the rest proceed? How shall we represent it to our minds? Every thing leads to the belief that it is not essentially distinguished from the ether, and consists in atoms of ether more or less strongly held together. It is objected that the ether is imponderable; but that is an unfounded objection. Doubtless it cannot be weighed; to do that we must compare a space filled with ether to a space empty of ether; and we are evidently unable to isolate this subtle agent, whose particles counterpoise each other with perfect equilibrium throughout the universe. Yet many facts attest its prodigious elasticity. A flash of lightning is nothing more than a disturbance of equilibrium in the ether, yet no one will deny that

lightning performs an immense work. However this may be, it is impossible to think of the energies that make up the atom otherwise than as of pure force, and the ether itself, whose existence is demonstrated by the whole of physics, can be no otherwise defined than by the attributes of force. It follows from this that atoms, the last conclusion of chemistry, and ether, the last conclusion of physics, are substantially alike, although they form two distinct degrees, two unequal values, of the same original activity. All those physico-chemical energies, as well as the analogous energies of life, only show themselves to us, save in rare exceptions, clothed with that uniform we call matter. A single one of these energies shows forth, stripped of this dress, and bare. It rules all the others, because it knows them all without their knowing it. It is not power merely, but consciousness besides. It is the soul. How define it otherwise than as force in its purest essence, since we look upon it, as on the marble of the antique, in splendid nakedness, which is radiant beauty too?

Whether we consider coarser matter which can be weighed and felt, or that more subtle, lively, and active matter we call ether, or again the spiritual principle, which is energy simple, we have then always before us only harmonious collections of forces, symmetrical activities, ordered powers, more or less conscious of the part they play in the infinite concert for which the Creator has composed the glorious music. Let us set aside for a moment the variety of groupings which determine the succession and the manifold aspects of these forces, and there will remain, as constituent principles of the web of the universe, as irreducible and primordial ingredients of the world, nothing but dynamic points, nothing but monads.

The term of the rigorous analysis of phenomena is, definitively, the conception of an infinity of centres of similar and unextended forces, of energies without forms, simple and eternal. We ask what these forces are, and we assert in answer that it is impossible to distinguish them from motion. Force may be conceived, but not shaped to the fancy. The clearest and truest thing we can say of it is, that it is an energy analogous to that whose constant and undeniable presence we feel dwelling in our deepest selves. "The only force of which we have consciousness," says Henry Sainte-Claire Deville, "is will." Our soul, which gives us consciousness of force, is also the type of it, in this sense that, if we wish to pierce to the elementary mechanisms of the world, we are imperiously driven to compare its primal activities with the only activity of which we have direct knowledge and intuition, that is to say, with that admirable spring of will, so prompt and sure, which permits us every moment to create and also to guide motion.

Motion may serve to measure force, but not to explain it. It is as subordinate to the latter as speech is to thought. In truth, motion is nothing else than the series of successive positions of a body in different points of space. Force, on the other hand, is the tendency, the

tension, which determines the body to pass continually from one to the other of these points; that is to say, the power by which this body, considered at any instant in its course, differs from the identical body at rest. Evidently this something which is in one of these two bodies and is not in the other, this something that mathematicians call the quantity of motion, which is transformed, on a sudden stoppage of motion, into a certain quantity of heat, this something is a reality, distinct from the trajectory itself; and yet nothing, absolutely nothing, outside of the inner revelation of our soul, gives us the means of understanding what this initial cause of the motive forces may be. The distinguished founder of the mechanical theory of heat, Robert Mayer, defines force to be "whatever may be converted into motion." There is no formula that so well expresses the fact of the independence and preëminence of force, nor so completely includes the assertion of the essential reality of a cause preëxisting motion. The idea of force is one of those elementary forms of thought from which we cannot escape, because it is the necessary conclusion, the fixed and undestroyable residue from the analysis of the world in the alembic of our minds. The soul does not find it out by discursive reasoning, nor prove it to itself by way of theorem or experiment; it knows it, it clings to it by natural and unconquerable affinity. We must say of force what Pascal said of certain fundamental notions of the same order: "Urging investigation further and further, we necessarily arrive at primitive words which cannot be defined, or at principles so clear that we can find no others which are clearer." When we have reached these principles, nothing remains but to study one's self with profoundest meditation, not striving to give an image to those things whose essence is that they cannot be imagined. From the most general and abstract point of view, then, matter is at once form and force, that is, there is no essential difference between these two modes of substance. Form is simply force circumscribed, condensed. Force is simply form indefinite, diffused. Such is the net result of the methodical inquiries of modern science, and one which forces itself on our minds, apart from any systematic premeditation. It is of consequence to add that the merit of having formulated it very clearly and noted its importance belongs to French contemporary philosophers, particularly to Charles Lévèque and Paul Janet.

II.

If the web of things, the essence of matter, is one single substance, who was the Orpheus under whose spell these materials gathered, ranged, and diversified themselves into natures of so many kinds? And, first of all, how can the extension of bodies proceed from an assembling of unextended principles? The answer to this first question does not seem difficult to us. Extension exists prior to matter. They are two distinct things, without any relation of causality or

finality. Matter no more proceeds from extension than extension proceeds from matter. This simple remark suffices to settle the difficulty of conceiving how the dimension of objects results from a group of dynamic points which have no dimension. Extension existing before every thing else, it is quite clear that, when certain primal energies come into union to give rise, through a thousand successive complications, to phenomena and to bodies, what they really produce is not the appearance of extension, which is the mere shadow of reality, but it is that collection of various and diverse activities which enable us to describe and define phenomena and bodies.

It is no longer a subject of doubt, in the minds of *savants* who have got beyond experimentation, that extension is an image and a show rather than an essential constituent property of bodies. The extension of bodies is a phenomenon which takes its rise in the collision of force with our minds. Charles de Rémusat, so long ago as 1842, gave an original and remarkable demonstration of this. He maintains that force is the cause of extension, meaning by that that the sensation of extension is a modification of our sensibility, occasioned by forces analogous to those which produce sensations of a more complex kind. When you experience an electric shock, you are struck. Percussion is the sensation of contact, in other words, of impulsion by something that has extension. Now, in this instance, Rémusat says, the cause of percussion, electricity, has no extension. Therefore, he adds, either electricity is nothing, or else it is a force which affects us in a way that may be compared to the effect of extension. So that a force, wanting the usual appearances of extension, may produce the same effects on us that a solid body in motion does. Within a few years a profound metaphysician, Magy, has pointed out by new arguments that corporeal extension is merely a show which springs from the internal reaction of the soul against the impression made on the sensorium, and which the soul translates to outward bodies, by a law analogous to that which makes it localize in the separate organs of sense the impression which it has nevertheless perceived only in the brain. Each sensation of taste, smell, light, or sound, is a phenomenon of psychological reaction which occurs in the soul when it is teased with a certain degree of energy by nerve-action, which in its turn depends on an outward action; but there is no relation of resemblance between the latter and the sensation it provokes. The ether, which, by its vibrations in unison with the elements of our retina, produces sensations of light in us, has in itself no luminosity. The proof of this is that two rays of light meeting under certain conditions may annul each other, and produce darkness. Now, Magy maintains that the subjectivity of extension is of the same order with that of light. Extension in general is explained by purely dynamic reasons, as readily as that particular extension is which serves as a kind of support for luminous phenomena, which evidently result from vibrations of the unextended

principles. Helmholtz, in his latest writings, fully adopts this doctrine of corporeal extension.

We thus see that there is no difficulty in reconciling extension with unextended forces, and the phenomena of extension with principles of action; but this is only the first part of the problem, and it becomes necessary now to ascend from these unextended forces and active principles to those more or less complex manifestations which make up the infinite universe, adorning space with imperishable variety. Let us imagine this universe filled with the greatest conceivable number of active principles, all identical, diffused uniformly throughout immensity, and consequently in a state of perfect equilibrium. All will be torpid in absolute repose, in which form without shape and force without spring will be as though they were not. Between a homogeneous, motionless substance, identical with itself throughout space at all points, and nihility, reason perceives no difference. In such a system, nothing has weight, for there is no attracting centre; heat is no more possible for it than light, since these two forms of energy are bound up with the existence of systems of unequal vibrations, of diversified media, and varying molecular arrangements. *A fortiori*, the phenomena of life will be incompatible with this universal unity of substance, this unchanging identity of force.

The objective existence of things, the coming into reality of phenomena, can only be conceived, therefore, as the work of a certain number of differentiations taking place in the deep of that universal energy of primal matter, which is the last result of our analysis of the world. Motion, of itself alone, is enough to explain a first attribute of that energy, namely, resistance, and its consequence, impenetrability; but this is only on the condition that this motion shall take place in various directions. Two forces urged in opposite directions, and coming to a meeting, manifestly resist each other. It is probably by collisions of this sort that those variable condensations of matter, and those heterogeneous groupings of which the world presents the spectacle, have been determined. A rotary movement, communicated to a mass without weight, can only engender concentric spheres, which gravitate toward each other in consequence of pressure by the interposing ether. The famous experiments of Plateau are decisive in this respect. That accomplished physicist introduces oil into a mixture of water and alcohol, having exactly equal density with the oil itself. He inserts a metallic strip into the midst of this mass of oil, which is free from the action of any force, and turns it about. The oil takes the form of a sphere, and, as soon as the rotation grows very rapid, breaks up, and parts into a number of smaller spheres. The celestial spheres were probably formed in the same way, and an exactly similar mechanical action produces those clear dew-drops, glittering like diamonds, on the leaves of plants.

All physical phenomena, whatever their nature, are at bottom only

manifestations of one and the same primordial agent. We can no longer question this general conclusion of all modern discoveries, Sénarmont explicitly says, though it is, as yet, impossible to formulate with precision its laws and its particular conditions. If this be true, and we hope we have proved it to be so, it is plain that those conditional particularities of which Sénarmont speaks, that is to say, those diversified manifestations of the sole agent to which he alludes, can depend only on differences in the motions which impel it. Now, the very existence of these differences necessarily implies a coördinating and regulating intelligence; but how much more extreme is the necessity for such a cause in chemical phenomena, which display such endless complications issuing from that primal energy to which every thing in the last analysis is reduced! We have seen that the variety of those stable and homogeneous energies known under the name of simple bodies, the number of which is now increased to sixty, depends on the variety of the vibrations that each one of these little worlds performs. This is the earliest intervention of a principle of difference. This principle does not merely determine the multiplication of simple bodies; it also acts in any one element with such intensity that the same element can acquire very unlike properties and attributes. What things are more heterogeneous than the diamond and charcoal, or than common phosphorus and amorphous phosphorus? Yet charcoal and diamond are chemically identical, just as the two sorts of phosphorus are. These cases of isomery, which are quite numerous, attest with the strongest evidence the excessive variability of which combinations of force are capable. When we see the same elements, combined in the same weight-proportions, produce sometimes harmless substances, sometimes terrible poisons, in one case evolve colorless or dingy products, in another brilliant hues, we become convinced that primal matter is of little consequence in comparison with the weaver who arranges its threads, and knows beforehand what the aspect of the web will be. Besides, it is not alone in the whole that the formative principle is displayed; it shows forth also in the elements, considered individually, since every one of them exhibits tendencies, elective affinities, that bear witness to some obscure instinct toward harmonious completion.

There is not only a prodigious variety in the disposition of the atoms which make up molecules, and in the arrangement of the molecules among themselves, but this arrangement is governed, besides, by admirable geometric laws. The atoms that make up molecules are not heaped and flung together at random and in disorder; they enter into composition only in fixed proportions and in fixed *directions*. Marc-Antoine Gaudin has proved, in a late treatise devoted entirely to these refined inquiries, the existence of some of the most important laws in the geometry of atoms. This ingenious and persevering writer demonstrates that all chemical molecules, whether they are fitted to

produce crystals or not, are formed by a symmetrical aggregation of atoms. The latter are arranged in equilibrium in two directions, perpendicular to each other, one parallel to the axis of grouping, and the other at right angles to that axis, so as always to compose a symmetrical figure. The most complicated bodies, so soon as they are brought under the law of definite proportions, and compose chemical species, are made up of molecules in which the atoms are grouped in prisms, in pyramids, in a word, in polyhedra more or less many-sided, but always of perfect regularity; so that, in this case, the differentiation is regulated with marvellous harmony.

We must now rise another degree, and pass from inorganic matter to living matter. What is it that distinguishes the latter from the former? When we make the answer depend on the results of direct experiment, nothing is easier than to establish the differential characteristics of living matter. In the first place, it is organized, that is, the anatomical elements, instead of being homogeneous and symmetrical in all points of their mass, are composed by the association of a certain number of different substances, in which carbon predominates, and which are termed immediate organic principles. Then these elements grow. At no time the same throughout, as to the substance which makes them up, they are in a state of unceasing molecular renewal, of constant metamorphosis, of simultaneous and continuous assimilation and disassimilation. Besides, the various properties these elements may exhibit, contractility, neurility, and so on, are, in consequence of the growing state that characterizes them, in so unstable a condition of equilibrium that the slightest variation in the surrounding medium is enough to occasion some change in the expression of their activity; in other words, they have excessive excitability and irritability. Such, at least, is the region within which physiology is limited; but the fact which it does not clearly enough bring out, yet the thing which is the distinctive mark of life, is the harmonious seeking for each other of all these vital monads, the disposition of biological energies to compose groups of which the end and the reason are found in what we call the individual. The differentiations of inorganic matter occur in molecules that are specific, in whatever bulk they are regarded. The differentiations of living matter take place only in individuals whose build and proportions are strictly determined. An iron bar, an iron crystal, and iron-dust, are all still iron. An organic substance fitted for life is nothing, whenever deprived of connection with an organism. It can display energy, can act; in a word, can be, so far as to be a living substance, only in virtue of taking place and rank in a certain whole, and assuming certain dependencies and connections with other more or less analogous substances. By itself it is not distinguished in essence from dead matter. It is raised to the rank and clothed with the dignity of life only from the time of its reception into that gathering of which the

steps all move toward the same end, which is, the functional action of the organism, and the perpetuation of the species.

What takes place in the ovule is a miniature image of what takes place in the universe. The differentiations occurring in that mucous drop are a copy of the differentiations unfolding and expanding in the ocean of the world. It is at first a microscopic mass, homogeneous, uniform in all its parts, a collection of energies identical with each other, and the group of which does not differ perceptibly from a drop of gelatine, hanging, hardly seen, from a needle's point. Yet soon a dull motion spontaneously stirs these nearly inert atoms, and this motion is expressed by a first condensation of the ovular or vitelline substance, which is the germinating vesicle. This passes off, but at the same time other vibrations arrange the molecules of this shapeless, transparent microcosm, in the order of more complicated groups. The vitelline substance swells toward the surface, where it forms the polar globules, while at the centre it thickens to produce the vitelline nucleus. This in turn cleaves and breaks into a great number of secondary nuclei, around each of which the ovular mass distributes itself while contracting. Instead of a single cell, the ovule, which has enlarged, is now found to contain a great number. These cells, called blastodermic, then tend to arrange themselves in two layers, two leaflets placed back to back, within which the elements of the embryo appear, and little by little develop, pursuing a continuous growth, in which forces becoming forms go on incessantly producing and multiplying new forces and new forms.

Now, these separations and distributions, these orderings and classifyings, these harmonies that are set up in the ovule to compose by slow degrees the structure of the embryo, reveal a principle of differentiation analogous to that which has caused the infinite variety of things we see come forth from the confused mass of cosmic energies. There is, as many biologists had felt assured, and as Coste has had the glory of clearly demonstrating in a work which is one of the noblest scientific monuments of this age, there is a force which gives reality, direction, life, to the forms of organized matter in the egg. All eggs are alike at first. There is a complete similitude in structure and substance between those which will produce a lion and those which will produce a mouse. The forms are identical, though the future of those forms is different. It is, as Coste very well says, that "beneath that form, and beyond what the eye views, there is something which sight cannot reach, something which contains in itself the sufficient reason for all those differences now concealed under unity of configuration, and to become visible only later." This guiding idea, which Coste has brought forward, and which is admitted by all physiologists at this day, is as far from issuing out of the elementary forces of nutrition as the painter's picture is from being the creature of his palette. Yet nothing in the ovule reveals its hidden and

potent virtuality. Claude Bernard, who has repeated Coste's ideas on this subject, dwells strongly on the guiding force which is in the egg, and those *savants* who agree with Robin in denying this force, so far as it acts on the totality of elements in the embryo, regard it at least as shared, distributed, and acting in each of these elements separately, which, at bottom, is the same thing. We see, in any case, that there is in the inmost depth, and there dates from the most rudimentary sketch of the organized being, the fixed and formed idea of those differences in choice and those sympathies in work whose system shall build up the individual. The differential coefficient of organized matter is thus of a far higher order than that of mineral matter. It is this which is a distinct and peculiar result from the impotence which experimental science betrays more plainly every day, when attempting to convert physico-chemical activities into energies of the vital order. Even could this conversion really be effected, and it is not metaphysically impossible that it might be, the existence of a spiritual principle of differentiation would be in no wise put in doubt. Hitherto, at least, such a conversion seems beyond the reach of man.

Something that yet more completely baffles his research, while commanding too his highest admiration, is the supreme degree of complexity together with refinement of that energy which is the soul. Human thought is the sum of all the forces of Nature, because it assimilates them all, while distinguishing between them, by the work that it performs upon sensations. Sensations are to thought what food is to growth. Growth is not a result of feeding; thought is not a result of sensations. Nutrition, in shaping the living organs, determines the differentiation of the concrete forms in the individual's substance; thought, in shaping general ideas, determines the differentiation of the abstract forces in the world. Thus thinking energy is as much superior to sensations as nutritive energy is to aliments. In another order of thought, we might compare the soul to a paper covered with writing in sympathetic ink. At ordinary temperatures, the letters are unseen, but they appear in fine color whenever brought near the fire. So the soul has within itself dim marks and confused shapes which sensation tints and brightens. We have seen that, in the mucous drop, a two hundred and fiftieth part of an inch through, called the ovule, the forces and tendencies of the whole nutritive and intellectual life of man lie prisoned and asleep. So, too, in that force without form or extension, which is the soul, there dwells a miniature picture of the whole universe, and, by some mystic grace of God, a dream, as it were, of that God himself. Thought consists in becoming acquainted with all the details of that picture in little, and unfolding its meaning. Thus, that which makes the whole reality of material things is form, and form, such as it is shown to us in the world, is at once a principle of differentiation and a principle of agreement; in other words, it is the work of an intelligence. Body and motion are mere phenomena. The

first is only an image of substance, the last an image of action; but substance and action both are only effects of intelligent force, that is, of activity operating in view of a result. That activity, however, presents infinitely varied degrees of condensation, and we may say, with Maudsley: "One equivalent of chemical force corresponds to several equivalents of lower force; and one equivalent of vital force to several equivalents of chemical force." It is thus that modern science unties the gordian knot of the composition of matter.

III.

A first exclusively analytical view of the world has led us to a first undeniable certainty, the existence of a principle of energy and motion. A second view of the universe, exclusively synthetic, leads us, as we have seen, to another certainty, which is the existence of a principle of differentiation and harmony. This principle is what is called spirit. Thus spirit is not substance, but it is the law of substance; it is not force, but it is the revealer of force. It is not life, but it makes life exist. It is not thought, but it is the consciousness of thought. A distinguished English *savant*, Carpenter, has said lately, with decisive clearness, "Spirit is the sole and single source of power." In a word, it is not reality, yet in it and by it realities are defined and differentiated, and consequently exist. Instead of saying that spirit is a property of matter, we should say that matter is a property of spirit. Of all the properties of matter, in fact, there is not one, no, not a single one, which is not bestowed on it by spirit. The true explanation, the only philosophy of Nature, is thus a kind of spiritualistic dynamism, very different from materialism, or from the mechanism of certain contemporary schools.

Materialism is false and imperfect, because it stops short at atoms, in which it localizes those properties for which atoms supply no cause, and because it neglects force and spirit, which are the only means we have, constituted as our souls are, of conceiving the activity and the appearings of beings. It is false and imperfect, because it stops half-way, and treats compound and resolvable factors as simple and irreducible ones; and because it professes to represent the world by shows, without attempting to explain the production of those shows. In a word, it sees the cause of diversity where it is not, and fails to see it where it does exist. The source of differentiations cannot be in energy itself; it must be in a principle apart from that energy, in a superior will and consciousness, of which we have doubtless only a dim and faulty idea, but as to which we can yet affirm that they have some analogy with the inner light which fills us, and which we shed forth from us, and which teaches us, by its mysterious contact with the outer world, the infinite order of the universe.

The danger from materialism is not, as we usually incline to think, corruption of morals by degradation of the soul. Too much

use, for censure's sake, has been made, against this system, of the seeming ease with which its professors have convinced themselves that they cut up by the roots the very principles of morality and duty. History proves, by examples too infamous, that barbarism and license are the privilege of no philosophic sect. The real enemies of society always have been, and always will be, the ignorant and the fanatical, and it must be frankly owned that, if these exist within the pale of materialism, there are quite enough of them outside. The danger in the doctrine which reverses the natural relation of things, and asserts that spirit is a product of matter, when in truth matter is a product of spirit, this danger is of another kind; materialism is fatal to the development of the experimental sciences themselves. If, in such a case, the example of men of genius might be appealed to, how eloquent would be the testimony of the two greatest physicists of this age, Ampère and Faraday, both so earnestly convinced, so religiously possessed by the reality of the unseen world! But there are other arguments. "All that we see of the world," says Pascal, "is but an imperceptible scratch in the vast range of Nature." The claim of mere experimentalism is that it may sentence men to the fixed and stubborn contemplation of this scratch. What folly! All the history of the development of the sciences proves that important discoveries all proceed from a different feeling, which is that of a continuation of forces beyond the limits of observation, and of a harmony in relations, overruling the singularities and deformities of detached experiences. To hedge one's self within what can be computed, weighed, and demonstrated, to trust such evidence only, and bar one's self inside the prison of the senses, to hush or scorn the suggestions of the spirit, our only true light, because it is a spark of the flame that vivifies all—this is, deny it or not, the condition and the subject state of materialism. Only reason can conceive the fixity, the generality, and the universality of relations, and all *savants* admit that the destiny of science is to establish laws possessing these three characteristics; but to admit that is to confess by implication that partial, incoherent, imperfect, relative details must undergo a refining, a thorough conversion, in the alembic of the mind, whence they issue, with so new an aspect and meaning, that what before seemed most important becomes as mere an accessory as it is possible to be, and that which looked most ephemeral takes its place among eternal things.

The conception of atoms dates from the highest antiquity. Leucippus and Democritus, the masters of Epicurus, several centuries before the Christian era, taught that matter is composed of invisible but indestructible corpuscles, the number of which is as boundless as the vastness of the space in which they are diffused. These corpuscles are solid, endowed with shape and motion. The difference of their forms regulates the difference of their movements, and consequently of their characteristics. The conception of a principle guiding these diversi-

ties, that is, of an intelligence as the supreme cause of differentiation, is not less ancient. "All was chaotic," Anaxagoras of Clazomene said; "an intelligence intervened, and regulated all." Plato, after defining matter as an existence very hard to understand, an eternal place, never perishing, and furnishing a stage of whatever begins to be, not the subject of sense and yet perceptible, and of which we only catch glimpses as in a dream, tells us that the supreme ruler "took this mass which was whirling in unchecked and unguided movement, and made order come out of disorder." And this ordering grows real in conformity with ideas, the prototypes of things, whose totality makes the divine essence itself. The world's activities are reflections of God's thoughts. To these two fundamental notions, that of atomism and that of idealism, Aristotle added a third, that of dynamism. As he holds, indeterminate matter, in the highest degree of abstraction, is without attributes. If it tends always toward form and action, that is because it contains a principle of power, a force. Force is in Aristotle's view the principle of form. The latter relates to substance. We have here the whole ancient philosophy regarding the world. Modern philosophy has taught us nothing different. Atomism, strengthened and widened by Descartes, and borrowed from him by Newton, is identical at bottom with that held by the teachers of Epicurus. In the same way, Leibnitz's dynamism is only a revival of Aristotle's. And, just as Descartes and Leibnitz reproduce the old Greek masters, contemporary science renews Descartes and Leibnitz.

"But what!" it will be said; "always repeating, never inventing, must that be the fixed doom of metaphysics?" Not so; these renewals contain continuous growth toward perfection. The old truth has been preserved, in its original sense, but it has been constantly illuminated and made exact in the lapse of time by happy efforts of speculative genius. Greek atomism had an immense chasm which Descartes filled by the conception of ether, the most marvellous of modern creations. Aristotle's dynamism was vague, and Leibnitz gave it precision by showing that the type and the fountain of force is and can be nothing else than spirit. He lifted the conception of force to the conception of soul. And what has been done in our days? We have computed the motion, we have detected the action, of that subtle ether, we have proved the absolute imperishableness of force, we have shown by many instances the fundamental identity of the appetitive and elective powers of chemistry and crystallography with those which psychology reveals. Here is the future of science and of metaphysics. Both will henceforth follow in their development the very course they have held to since the first day; they have never, like Penelope, destroyed yesterday's work the day after. They have pursued the same end with continuous advance, that is, the conception of invisible principles, and of the ideal essence of things. This end will remain the ever unattained goal of their ambition. The farther we shall ad-

vance, the more clearly and convincingly will they persist in defining those primal forces and elementary activities half guessed at from the very dawn of thought. Never false to themselves, they will always, at whatever point in history we appeal to them, represent the human soul unchanging in its nature, its powers, and its hopes. Let them never muse over the mournful question whether the work of the past will not vanish at some time without leaving a trace. All of it will survive, and from this confidence those who strive to increase the sum of knowledge draw their courage and consolation.

The conceptions of matter now entertained agree not only with the boldest deductions of most splendid discoveries of contemporary science, as well as with the oldest truths and the most instinctive faiths of humanity, but also with those loftier convictions, more precious and as solid, which form our moral and religious inheritance, and the crowning prerogative of our nature. The most advanced science rejects none of the traditions and objects to none of the great and lasting sentiments of past ages. On the contrary, it fixes the stamp of certainty on truths hitherto lacking adequate proofs, and rescues from the attacks of skepticism all that it coveted as its prey. No proof of the soul's immortality is so strong as that we have drawn from the necessary simplicity and eternity of all the principles of force. Nothing bears witness so powerfully to the majestic reality of a God as the spectacle of those diversities, all harmonious, which rule the infinite range of forces, and bind in unity the ordered pulses of the world. It is enough to fix the truth that the moral greatness and the intellectual dignity of a nation must always be measured by the standard of the esteem and credit it accords to high metaphysical speculations, and chiefly to such as relate to the constitution of matter. Meditation on the constitution of matter is the best method of teaching us to know spirit, and to understand that every thing must be referred to it, because from it every thing flows.—*Revue des Deux Mondes.*

THE GREAT NEBULA IN ORION.

By R. A. PROCTOR, B. A.

DURING the first four months of the year, the constellation Orion is very favorably situated for observation in the evening. This magnificent asterism is more easily recognized than the Great Bear, Cassiopeia's Chair, or the fine festoon of stars which adorns the constellation Perseus. There is, indeed, a peculiarity about Orion which tends considerably to facilitate recognition. The other constellations named above gyrate round the pole in a manner which presents them

to us in continually-varying positions. It is not so with Orion. Divided centrally by the equator, the mighty hunter continues twelve hours above and twelve hours below the horizon. His shoulders are visible somewhat more, his feet somewhat less, than twelve hours. When he is in the south, he is seen as a giant with upraised arms, erect, and having one knee bent, as if he were ascending a height. Before him, as if raised on his left arm, is a curve of small stars, forming the shield, or target of lion's skin, which he is represented as uprearing in the face of Taurus. When Orion is in the east, his figure is inclined backward; when he is setting, he seems to be bent forward, as if rushing down a height; but he is never seen in an inverted position, like the northern constellations.

And we may note, in passing, that the figure of Orion, as he sets, does not exactly correspond with the image presented in that fine passage in "Maud:"

> "I arose, and all by myself, in my own dark garden-ground,
> Listening now to the tide, in its broad-flung shipwrecking roar,
> Now to the scream of a maddened beach dragged down by the wave,
> Walked in a wintry wind, by a ghastly glimmer, and found
> The shining daffodil dead, and Orion low in his grave;"

and again, toward the end of the poem:

> ". . . . It fell on a time of year
> When the face of night is fair on the dewy downs,
> And the shining daffodil dies, and the charioteer
> And starry Gemini hang like glorious crowns
> Over Orion's grave low down in the west."

I would not, however, for one moment, be understood as finding fault with these passages of Tennyson's finest poem. Detached from the context, the image is undoubtedly faulty; but there is a correctness in the very incorrectness of the image, placed as it is in the mouth of one

> "Raging alone as his father raged in his mood;"

brooding evermore on his father's self-murder:

> "On a horror of shattered limbs . . . .
> Mangled, and flattened, and crushed."

Let us pass on, however, to the subject of our paper.

Beneath the three bright stars which form the belt of Orion are several small stars, ranged, when Orion is in the south, in a vertical direction. These form the sword of the giant. On a clear night it is easy to see that the middle star of the sword presents a peculiarity of appearance: it shines as through a diffused haze. In an opera-glass this phenomenon is yet more easily recognizable. A very small telescope exhibits the cause of the peculiarity, for it is at once seen that

what seemed a star is, in reality, a mass of small stars intermixed with a diffused nebulosity.

It is very remarkable circumstance that Galileo, whose small telescope, directed to the clear skies of Italy, revealed so many interesting phenomena, failed to detect

> "That marvellous round of milky light
> Below Orion."

It would not, indeed, have been very remarkable if he had simply failed to notice this object. But he would seem to have directed his attention for some time especially to the region in the midst of which Orion's nebula is found. He says: "At first I meant to delineate the whole of this constellation; but, on account of the immense multitude of stars—being also hampered through want of leisure—I left the completion of this design till I should have another opportunity." He therefore directed his attention wholly to a space of about ten square degrees, between the belt and sword, in which space he counted no less than 400 stars. What is yet more remarkable, he mentions the fact that there are many small spots on the heavens shining with a light resembling that of the Milky-Way (*complures similis coloris areolæ sparsim per æthera subfulgeant*); and he even speaks of nebulæ of this sort in the head, and belt, and *sword* of Orion. He asserts, however, that, by means of his telescope, these nebulæ were distinctly resolved into stars—a circumstance which, as we shall see presently, renders his description wholly inapplicable to the great nebula. Yet the very star around which (in the naked-eye view) this nebula appears to cling, is figured in Galileo's drawing of the belt and sword of Orion!

It seems almost inconceivable that Galileo should have overlooked the nebula, assuming its appearance in his day to have resembled that which it has at present. And, as it appears to have been established that, if the nebula has changed at all during the past century, it has changed very slowly indeed, one can scarcely believe that in Galileo's time it should have presented a very different aspect. Is it possible that the view suggested by Humboldt is correct—that Galileo did not see the nebula because he did not *wish* to see it? "Galileo," says Humboldt, "was disinclined to admit or assume the existence of starless nebulæ." Long after the discovery of the great nebula in Andromeda—known as the "transcendently-beautiful queen of the nebulæ"—Galileo omitted all mention in his works of any but starry nebulæ. The last-named nebula was discovered in 1614 by Simon Marius, whose claims to the discovery of Jupiter's satellites had greatly angered Galileo, and had called forth a torrent of invective, in which the Protestant German was abused as a heretic by Galileo, little aware that he would himself, before long, incur the displeasure of the Church. If we could suppose that an unwillingness, either to confirm his rival's

discovery of a starless nebula, or to acknowledge that he had himself fallen into an error on the subject of nebulæ, prevented Galileo from speaking about the great nebula in Orion, we should be compelled to form but a low opinion of his honesty. It happens too frequently that—

> "The man of science himself is fonder of glory, and vain—
> An eye well-practised in Nature, a spirit bounded and poor."

That Hevelius, the "star-cataloguer," should have failed to detect the Orion nebula is far less remarkable; for Hevelius objected to the use of telescopes in the work of cataloguing stars. He determined the position of each star by looking at the star through minute holes or pinnules, at the ends of a long rod attached to an instrument resembling the quadrant.

The actual discoverer of the great nebula was Huyghens, in 1656. The description he gives of the discovery is so animated and interesting that we shall translate it at length. He says:

"While I was observing the variable belts of Jupiter, a dark band across the centre of Mars, and some indistinct phenomena on his disk, I detected among the fixed stars an appearance resembling nothing which had ever been seen before, so far as I am aware. This phenomenon can only be seen with large telescopes such as I myself make use of. Astronomers reckon that there are three stars in the sword of Orion, which lie very close to each other. But, as I was looking, in the year 1656, through my 23-feet telescope, at the middle of the sword, I saw, in place of one star, no less than twelve stars, which, indeed, is no unusual occurrence with powerful telescopes. Three of these stars seemed to be almost in contact, and with these were four others which shone as through a haze, so that the space around shone much more brightly than the rest of the sky. And, as the heavens were serene and appeared very dark, there seemed to be a gap in this part, through which a view was disclosed of brighter heavens beyond. All this I have continued to see up to the present time" (the work in which these remarks appear, the "Systema Saturnium," was published in 1659), "so that this singular object, whatever it is, may be inferred to remain constantly in that part of the sky. I certainly have never seen any thing resembling it in any other of the fixed stars. For other objects once thought to be nebulous, and the Milky-Way itself, show no mistiness when looked at through telescopes, nor are they any thing but congeries of stars thickly clustered together."

Huyghens does not seem to have noticed that the space between the three stars he described as close together is perfectly free from nebulous light, insomuch that, if the nebula itself is rightly compared to a gap in the darker heavens, this spot resembles a gap within the nebula. And, indeed, it is not uninteresting to notice how comparatively inefficient was Huyghens's telescope, though it was nearly eight yards in focal length. A good achromatic telescope two feet long

would reveal more than Huyghens was able to detect with his unwieldy instrument.

Dominic Cassini soon after discovered a fourth star near the three seen by Huyghens. The four form the celebrated *trapezium*, an object interesting to the possessors of moderately good telescopes, and which has also been a subject of close investigation by professed astronomers. Besides the four stars seen by Cassini, there have been found five minute stars within and around the trapezium. These tiny objects seem to shine with variable brilliancy; for sometimes one will surpass the rest, while at others it will be almost invisible.

After Cassini's discovery, pictures were made of the great nebula by Picard, Le Gentil, and Messier. These present no features of special interest. It is as we approach the present time, and find the great nebula the centre of quite a little warfare among astronomers—now claimed as an ally by one party, now by their opponents—that we begin to attach an almost romantic interest to the investigation of this remarkable object.

In the year 1811, Sir W. Herschel announced that he had (as he supposed) detected changes in the Orion nebula. The announcement appeared in connection with a very remarkable theory respecting nebulæ generally—Herschel's celebrated hypothesis of the conversion of some nebulæ into stars. The astronomical world now heard for the first time of that self-luminous nebulous matter, distributed in a highly-attenuated form throughout the celestial regions, which Herschel looked upon as the material from which the stars have been originally formed. There is an allusion to this theory in those words of the Princess Ida:

> "There sinks the nebulous star we call the Sun,
> If that hypothesis of theirs be sound."

And in the teaching of "comely Psyche:"

> "This world was once a fluid haze of light,
> Till toward the centre set the starry tides,
> And eddied into suns that, wheeling, cast
> The planets."

Few theories have met with a stranger fate. Received respectfully at first on the authority of the great astronomer who propounded it—then in the zenith of his fame—the theory gradually found a place in nearly all astronomical works. But, in the words of a distinguished living astronomer, "The bold hypothesis did not receive that confirmation from the labors of subsequent inquirers which is so remarkable in the case of many of Herschel's other speculations." It came to pass at length that the theory was looked upon by nearly all English astronomers as wholly untenable. In Germany it was never abandoned, however, and a great modern discovery has suddenly brought it into general favor, and has in this, as in so many other instances,

vindicated Herschel's claim to be looked upon as the most clear-sighted, as well as the boldest and most original, of astronomical theorizers.

Herschel had pointed out various circumstances which, in his opinion, justified a belief in the existence of a nebulous substance—fire-mist or star-mist, as it has been termed—throughout interstellar space. He had discovered and observed several thousand nebulæ, and he considered that among these he could detect traces of progressive development. Some nebulæ were, he supposed, comparatively *young;* they showed no signs of systematic aggregation or of central condensation. In some nebulæ he traced the approach toward the formation of subordinate centres of attraction; while in others, again, a single centre began to be noticeable. He showed the various steps by which aggregation of the former kind might be supposed to result in the formation of star-clusters, and condensation of the latter kind into the formation of conspicuous single stars.

But it was felt that the strongest part of Herschel's case lay in his reference to the great nebula of Orion. He pointed out that, among all the nebulæ which might be reasonably assumed to be star-systems, a certain proportionality had always been found to exist between the telescope which first detected a nebula and that which effected its resolution into stars. And this was what might be expected to happen with star-systems lying beyond our galactic system. But how different is this from what was seen in the case of the Orion nebula! Here is an object so brilliant as to be visible to the naked eye, and which is found, on examination, to cover a large region of the heavens. And yet the most powerful telescopes had failed to show the slightest symptom of resolution. Were we to believe that we saw here a system of suns so far off that no telescope could exhibit the separate existence of the component luminaries, and therefore (considering merely the observed extent of the nebula, which is undoubtedly but a faint indication of its real dimensions) so inconceivably enormous in extent that the star-system of which our sun is a member shrinks into nothingness in comparison? Surely it seemed far more reasonable to recognize in the Orion nebula but a portion of our galaxy—a portion very vast in extent, but far inferior to that "limitless ocean of universes" presented to us by the other view.

And when Sir W. Herschel was able, as he thought, to point to changes taking place within the Orion nebula, it seemed yet more improbable that the object was a star-system.

But now telescopes more powerful than those with which the elder Herschel had scanned the great nebula were directed to its examination. Sir John Herschel, following in his father's footsteps, applied himself to the diligent survey of the marvellous nebula with a reflecting telescope 18 inches in aperture. He presented the nebula to us as an object of which "the revelation of the 10-feet telescope was but the

mere rudiment." Strange outlying wisps and streamers of light were seen, extending far out into space. Yet more strange seemed the internal constitution of the object. So strange, indeed, did the nebula appear, "so unlike what had hitherto been known of collections of stars," that Sir John Herschel considered the evidence afforded by its appearance as sufficient to warrant the conclusion of a non-stellar substance.

But this eminent astronomer obtained a yet better view of the great nebula when he transported to the Cape of Good Hope an instrument equal in power to that which he had applied to the northern heavens. In the clear skies of the Southern Hemisphere the nebula shines with a splendor far surpassing that which it has in northern climes. It is also seen far higher above the horizon. Thus the drawing which Sir J. Herschel was able to execute during his three years' residence at the Cape is among the best views of the great nebula that have ever been taken. But, even under these favorable circumstances, Sir John records that "the nebula, through his great reflector, showed not a symptom of resolution."

Then Lassell turned his powerful mirror, two feet in diameter, upon the unintelligible nebula. But, though he was able to execute a remarkable drawing of the object, he could discern no trace of stellar constitution.

In 1845 Lord Rosse interrogated the great nebula with his three-feet mirror. Marvellous were the complexity and splendor of the object revealed to him, but not the trace of a star could be seen.

The end was not yet, however. Encouraged by the success of the three-feet telescope, Lord Rosse commenced the construction of one four times as powerful. After long and persistent labors, and at a cost, it is said, of £30,000, the great Parsonstown reflector, with its wonderful six-feet speculum, was directed to the survey of the heavens. At Christmas, 1845, while the instrument was yet incomplete, and in unfavorable weather, the giant tube was turned toward the Orion nebula. Prof. Nichol was the first who saw the mysterious object as pictured by the great mirror. Although the observation was not successful so far as the resolution of the nebula was concerned, yet Nichol's graphic account of the telescope's performance is well worth reading:

"Strongly attracted in youth by the lofty conceptions of Herschel," he writes, "I may be apt to surround the incident I have to narrate with feelings in so far of a personal origin and interest; but, unless I greatly deceive myself, there are few who would view it otherwise than I. With an anxiety natural and profound, the scientific world watched the examination of Orion by the six-feet mirror; for the result had either to confirm Herschel's hypothesis in so far as human insight ever could confirm it, or unfold among the stellar groups a variety of constitution not indicated by those in the neighborhood of

our galaxy. Although Lord Rosse warned me that the circumstances of the moment would not permit me to regard the decision then given as absolutely final, I went in breathless interest to the inspection. Not yet the veriest trace of a star! Unintelligible as ever, *there* the nebula lay; but how gorgeous its brighter parts! How countless those streamers branching from it on every side! How strange, especially that large horn on the north, rising in relief from the black skies like a vast cumulous cloud! It was thus still possible that the nebula was irresolvable by human art; and so doubt remained. *Why* the concurrence of every favorable condition is requisite for success in such inquiries may be readily comprehended. The object in view is to discern, *singly*, sparkling points, small as the point of a needle, and close as the particles of a handful of sand; so that it needs but the smallest unsteadiness in the air, or imperfection in the shape of the reflecting surface, to scatter the light of each point, to merge them into each other, and present them as one mass."

Before long, Lord Rosse, after regrinding the great mirror, obtained better views of the mysterious nebula. Even now, however, he could use but half the power of the telescope, yet at length the doubts of astronomers as to the resolvability of the nebula were removed. "We could plainly see," he wrote to Prof. Nichol, "that all about the trapezium was a mass of stars, the rest of the nebula also abounding with stars, and exhibiting the characteristics of resolvability strongly marked." These views were abundantly confirmed by subsequent observations with the great mirror.

It will surprise many to learn that even Lord Rosse's great reflector is surpassed in certain respects by some of the exquisite refractors now constructed by opticians. As a light-gatherer the mirror is, of course, unapproachable by refractors. Even if it were possible to construct an achromatic lens six feet in diameter, yet, to prevent flexure, a thickness would have to be given to the glass which would render it almost impervious to light, and therefore utterly useless. But refractors have a power of definition not possessed by large reflectors. With a refractor eight inches only in aperture, for instance, Mr. Dawes has obtained better views of the planets (and specially of Mars) than Lord Rosse's six-feet speculum would give under the most favorable circumstances. And, in like manner, the performance of Lord Rosse's telescope on the Orion nebula has been surpassed—so far as resolution into discrete stars is concerned—by the exquisite defining power of the noble refractor of Harvard College (U. S.). By means of this instrument, hundreds of stars have been counted within the confines of the once intractable nebula.

It seemed, therefore, that all doubt had vanished from the subject which had so long perplexed astronomers. "That was proved to be *real*," Nichol wrote, "which, with conceptions of space enlarged even as Herschel's, we deemed *incomprehensible*."

Yet, even at this stage of the inquiry, there were found minds bold enough to question whether a perfectly satisfactory solution of the great problem had really been attained. Nor is it difficult, I think, to point out strong reasons for such doubts. I shall content myself by naming one which has always appeared to me irresistible.

The Orion nebula as seen in powerful telescopes covers a large extent of the celestial sphere. According to the Padre Secchi, who observed it with the great Merz refractor of the observatory at Rome, the nebulous region covers a triangular space, the width of whose base is some eight times, while its height is more than ten times as great as the moon's apparent diameter—a space more than fifty times greater than that covered by the moon. Now, I do not say that it is inconceivable that an outlying star-system, so far off as to be irresolvable by any but the most powerful telescopes, should cover so large a space on the heavens. On the contrary, I do not believe that a galaxy resembling our own would be resolvable at all, unless it were so near as to appear much larger than the Orion nebula. I believe astronomers have been wholly mistaken in considering any of the nebulæ to be such systems as our own. There may be millions of such systems in space, but I am very certain no telescope we could make would suffice to resolve any of them. But, what I do consider inconceivable is, that a nebula extending so widely, and placed (as supposed) beyond our system, should yet appear to cling (as the Orion nebula undoubtedly does) around the fixed stars seen in the same field with it. So strongly marked is this characteristic, that Sir John Herschel (who failed, apparently, to see its meaning) mentions among others no less than four stars—one of which is the bright middle star of the belt—as "involved in *strong* nebulosity," while the intermediate nebulosity is only just traceable. The probability that this arrangement is accidental is so small as to be almost evanescent. However, as I have said, English astronomers, almost without a dissentient voice, accepted the resolution of the nebula as a proof that it represents a distant star-system resembling our own galactic system, but far surpassing it in magnitude.

The time came, however, when a new instrument, more telling even than the telescope, was to be directed upon the Orion nebula, and with very startling results. The spectroscope had revealed much respecting the constitution of the fixed stars. We had learned that they are suns resembling our own. It remained only to show that the Orion nebula consists of similar suns, in order to establish beyond all possibility of doubt the theories which had been so complacently accepted. A very different result rewarded the attempt, however. When Dr. Huggins turned his spectroscope toward the great nebula, he saw, in place of a spectrum resembling the sun's, *three bright lines only!* A spectrum of this sort indicates that the source of light is a *luminous gas*, so that, whatever the Orion nebula may be, it is most certainly *not* a congeries of suns resembling our own.

It would be unwise to theorize at present on a result so remarkable. Nor can we assert that Herschel's *speculations* have been confirmed, though his general reasoning has been abundantly justified. Astronomers have yet to do much before they can interpret the mysterious entity which adorns Orion's sword. On every side, however, observations are being made which give promise of the solution of this and kindred difficulties. We have seen the light of comets analyzed by the same powerful instrument; and we learn that the light from the tail and coma is similar in quality (so far as observation has yet extended) to that emitted from the Orion nebula. We see, therefore, that in our own solar system we have analogues of what has been revealed in external space. I would not, indeed, go so far as to assert that the Orion nebula is a nest of cometic systems; but I may safely allege that there is now not a particle of evidence that the nebula lies beyond our galaxy.

Nor need we doubt the accuracy of Lord Rosse's observations. More than a year before his death, indeed, he mentioned to Dr. Huggins that "the *matter* of the great nebula in Orion had not been resolved by his telescope. In some parts of the nebula he observed a large number of exceedingly minute *red* stars. These red stars, however, though apparently *connected* with the irresolvable blue material of the nebula, yet seemed to be distinct from it."

The whole subject seems to be as perplexing as any that has ever been submitted to astronomers. Time, however, will doubtless unravel the thread of the mystery. We may safely leave the inquiry in the hands of the able observers and physicists whose attention has been for a long time directed toward it. And we need only note, in conclusion, that in the Southern Hemisphere there exists an object equally mysterious—the great nebula round η Argus—which has yielded similar results when tested with the spectroscope. The examination of this mysterious nebula, associated with the most remarkable variable in the heavens—a star which at one time shines but as a fifth-magnitude star, and at another exceeds even the brilliant Canopus in splendor—may, for aught that is known, throw a new light on the constitution of the great Orion nebula.—*Fraser's Magazine.*

OLD CONTINENTS.

By Prof. A. C. RAMSAY,
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FOR many years the stratified formations in general were described in manuals of geology as of marine origin, with the exception perhaps of part of the Coal-measures, and more unequivocally of the Purbeck and Wealden beds, and the fresh-water strata of parts of the Eocene and Miocene series. Even now the Old Red

Sandstone, as distinct from the marine Devonian rocks, is only occasionally and hesitatingly allowed to have a fresh-water origin, in spite of the statement made by Mr. Godwin-Austen long ago, that it was deposited in lakes.

My present object is to prove that, in the British Islands, all the great formations of a red color, and which are partly of Palæozoic, and partly of Mesozoic or Secondary age, were deposited in large inland lakes, fresh or salt; and if this can be established, then there was a long continental epoch in this part of the world comparable to, and as important in a physical point of view as any of, the great continents of the present day.

The Upper Silurian rocks of Shropshire, Herefordshire, Monmouthshire, and South Wales, are succeeded immediately by the Old Red Sandstone series, and there is no unconformity between them.

The teeming life of the Upper Silurian seas, in what is now Wales and the adjoining counties, continued in full force right up to the narrow belt of passage-beds which marks the change from Silurian brown muddy sands into lower Old Red Sandstone. In these transition beds on the contrary, genera, species, and often individuals, are few in number and sometimes dwarfed in size, the marine life rapidly dwindles away, and in the very uppermost Silurian beds land-plants appear, consisting of small pieces of undetermined twigs and the spore-cases of Lycopodiaceæ (*Pachytheca spherica*). Above this horizon the strata become red.

The poverty in number and the frequent small size of the shells in the passage-beds indicate a change of conditions in the nature of the waters in which they lived; and the plants alluded to clearly point to the close neighborhood of a land, of which we have no direct signs, in the vast development of a purely marine fauna in lower portions of the Ludlow strata. In the Ludlow bone-beds the fish-remains, *Onchus* and *Sphagodus*, and the large numbers of marine Crustacea, almost entirely trilobitic in the Ludlow rocks, indicate a set of conditions very unlike those that prevailed when the passage-beds and the lower strata of the true Old Red Sandstone were deposited, in both of which new fish appear, trilobites are altogether absent, and are more or less replaced by Crustacea of the genera *Pterygotus* and *Eurypterus*, one of which, *Eurypterus Symondsii*, has only been found in the lower Old Red Sandstone. Neither are there any mollusca in the Old Red Sandstone, excepting where that formation passes at the top into the Carboniferous rocks. All these circumstances indicate changes of conditions which were, I believe, of a geographical kind, and connected with the appearance in the area of fresh water.

The circumstances which marked the passage of the uppermost Silurian rocks into Old Red Sandstone seem to me to have been the following: First, a shallowing of the sea, followed by a gradual alteration in the physical geography of the district, so that the area became

changed into a series of mingled fresh and brackish lagoons, which finally, by continued terrestrial changes, were converted into a great fresh-water lake, or, if we take the whole of Britain and areas now sea-covered beyond, into a series of lakes. The occurrence of a few genera or even species of fish and Crustacea common to the salt, brackish, or fresh waters, does not prove that the passage-beds and those still higher are truly marine. At the present day, animals commonly supposed to be essentially marine are occasionally found inhabiting fresh water. In the inland fresh lakes of Newfoundland, seals, which never visit the sea, are common and breed freely. The same is the case in Lake Baikal, 1,280 feet above the sea-level, in Central Asia; and, though these facts bear but slightly on my present subject, seals being air-breathing Mammalia, yet in the broad mouth of the Amazon, far above the tidal influx of sea-water, marine mollusca and other kinds of life are found, and in some of the lakes in Sweden there are marine Crustacea. This may be easily accounted for in the same way that I now attempt to account for analogous peculiarities in the Old Red Sandstone. These Swedish lakes were submerged during the Glacial period, and remained as deep basins while the land was emerging, and, after its final emergence, the salt-waters of the lakes freshened so slowly that some of the creatures inhabiting them had time by degrees to adjust themselves to new and abnormal conditions.

In further illustration of the subject let us suppose a set of circumstances such as the following: By long-continued upheaval of the mouth of the Baltic (a process now going on), its waters, already brackish in the Gulfs of Bothnia and Finland, would eventually become fresh, and true lacustrine strata over that area would succeed and blend into the marine and brackish water-beds of earlier date. Something of this kind I conceive to have marked the transition from the Upper Silurian beds into the Old Red Sandstone. Again: if by changes in the physical geography of the area, of a continental kind, a portion of the Silurian sea got isolated from the main ocean, more or less like the Caspian and the Black Sea, then the ordinary marine conditions of the "passage-beds," accompanied by some of the life of the period, might be maintained for what, in common language, seems to us a long time. There is geological proof that the Black Sea was once united to the Caspian, the two forming one great brackish lake. Since they were disunited and the Bosporus opened, the Black Sea has, it may be inferred, been steadily freshening; and it is easy to conceive that, by the reclosing of the Bosporus (a comparatively small geographical change), it might in the course of time again be converted into a fresh lake. At present a great body of salt-water is constantly being poured out through the Bosporus, and its place taken by the fresh waters of the Danube and other rivers, while, owing to the uncongenial quality of the freshening sea, some of the Black-Sea shells are strangely distorted, as was shown by Edward Forbes.

Or, if we take the Caspian alone as an example, there we have a brackish inland sea which was once joined to the ocean, as proved by its molluscan fauna. Changes in physical geography have taken place of such a kind that the Caspian is now separated from the ocean, while its waters, gradually growing salter by evaporation, are still inhabited by a poor and dwarfed marine molluscan fauna. If by increase of rainfall the Caspian became freshened, evaporation not being equal to the supply of water poured in by rivers, it would by-and-by, after reaching the point of overflow, be converted into a great fresh-water lake larger in extent than the whole area of Great Britain. Under these circumstances, in the Caspian area we should have a passage more or less gradual from marine to fresh-water conditions, such as I conceive to have marked the advent of the Old Red Sandstone.

The total absence of marine shells, and the nature of the fossil fishes of the Old Red Sandstone, also help to prove its fresh-water origin, for we find the nearest living analogues of the fishes in the Polypterus of the rivers of Africa, the Ceratodus of Australia, and in less degree in the Lepidosteus of North America. In the upper beds of the formation there is distinct proof of fresh water, in shells of the genus Anodonta mingled with ferns and other land-plants.

One other sign of the *inland* character of these waters remains to be mentioned—I mean the red color of their strata. As a general rule, all the great ocean formations, such as the Silurian, Carboniferous Limestone and Jurassic series, are gray, blue, brown, yellow, or of some such color. The marls and sandstones of the Old Red series are red because each grain of sand or mud is incrusted with a thin pellicle of peroxide of iron. When this coloring-matter is discharged the rock becomes white, and the iron that induces the strong red color in the New Red Marl, which much resembles that of the Old Red series, is found to be under two per cent. of the whole. I cannot conceive how peroxide of iron could have been deposited from solution in a wide and deep sea by any possible process, but, if carbonate of iron were carried in solution into lakes, it might have been deposited as a peroxide through the oxidizing action of the air and the escape of the carbonic acid that held it in solution. It is well known that ferruginous mud and ores of iron are deposited in the lakes of Sweden at the present day. These are periodically dredged for economic purposes by the proprietors till the layer is exhausted, and after a sufficient interval they renew their dredging operations and new deposits are found. With a difference the case is somewhat analogous to the deposition of peroxide of iron that took place in the Old Red Sandstone waters. It is obvious that common pink mud might have been formed from the mechanical waste of red granite, gneiss, or other red rocks in which pink felspars are found, but such felspars are tinted all through with the coloring-matter, and such a tint is very different from the deep-red

color that was produced by the encasing of each individual grain of sediment with a thin pellicle of peroxide of iron.

The proof that the Old Red Sandstone was deposited in inland lakes is strengthened by a similar case in well-known ancient inland sheets of water, as shown by the red marls of the Miocene lakes of Central France.

It is known that in Ireland and in Scotland the Old Red Sandstone consists of two divisions, upper and lower, the upper division lying quite unconformably on the lower. In South Wales there are symptoms of the same kind of unconformity, for the upper beds of the Old Red Sandstone gradually overlap the lower strata. But, on consideration, this last circumstance does not appear to present any real difficulty with regard to the physical conditions of the period. If the great hollow in which the Dead Sea lies were gradually to get filled with fresh water and silted up, 1,300 feet of strata might be added above the level of the present surface of the water, without taking into account the depth of the sea and the deposits that have already been formed; and the upper strata all round would overlap the lower, apparently much as the Old Red Sandstone strata do in Wales and the adjoining counties. If the Caspian and other parts of the Asiatic area of inland drainage got filled with water, the same general results would follow.

Neither does the decided unconformity between the Upper and Lower Old Red Sandstones both in Ireland and in Scotland present any insuperable difficulty as to the fresh-water origin of the strata. It indicates only great disturbance and denudation, and a long lapse of geological time unrepresented by strata between the disturbance and denudation of the older beds and the deposition of the newer. Here also we have a parallel case in times comparatively recent, for the fresh-water Miocene strata of Switzerland and the adjacent countries have been exceedingly disturbed, heaved up into mountains, and subjected to great denudation, while at a much later geological date—that of to-day—we have all the large fresh-water lakes that diversify the country north of the Alps in the same general area.

It is unnecessary to dilate on the well-known continental aspect of a large part of the Carboniferous strata which succeed the Old Red Sandstone, especially of the Coal-measures, which in the north of England and in Scotland are not confined to the upper parts of the series, but reach down among strata which elsewhere are only represented by the marine beds of the Carboniferous Limestone. The soils (underclays), forests, and peat-mosses of the period, now beds of coal; the sun-cracks, rain-pittings, bones, and footprints of Labyrinthodont Amphibia on mud now hardened into shale; the estuarine and fresh-water shells—all point to vast marshes and great deltoid deposits, formed in a country which underwent many changes in its physical geography, and yet retained its identity throughout.

I will now discuss the conditions under which the British Permian strata were deposited. These rocks in their general characters very much resemble the Rothliegende, Kupferschiefer or Marl-slate, and Zechstein of the Thuringerwald and other parts of Germany, with this difference, that where the English Magnesian Limestone (Zechstein) is in force between Tynemouth and Nottingham, there are no red sandstones, marls, and conglomerates (Rothliegende), between the limestone and the Coal-measures, and in all the other parts of Britain where the red sandstones, etc., occur, there is only in two instances a little magnesian limestone lying, not at the top, but in the midst of, or interstratified with, the sandy and marly series.

The Permian marls, sandstones, conglomerates, and subangular breccias of Warwickshire, Staffordshire, Shropshire, Lancashire, North Wales, the Vale of Eden, and the south of Scotland, are all red, and, in fact, I nowhere recollect any important gray, yellow, or brown shales and sandstones among them. It is, however, foreign to my present purpose to discuss minor stratigraphical details, or any questions connected with English and Continental equivalent geological horizons of Permian age, nor is it necessary to do more than allude to the disturbances and denudations which preceded the unconformable deposition of our Permian strata, on all or any of the Palæozoic formations of earlier date. It is enough if I am able to show good reason for my belief that *all* of our Permian strata were deposited, not in the sea, but in the inland waters of lakes, which were probably mostly salt, but may possibly sometimes have been fresh or brackish.

As with the red strata of the Old Red Sandstone, so I consider that the red coloring-matter of the Permian sandstones and marls is due to the precipitation of peroxide of iron in a lake or lakes, in the manner already stated, and the nearly total absence of sea-shells, in by far the largest part of the areas occupied by the strata colored red, strongly points to this conclusion. There is other evidence bearing upon the question. The British plants of Permian age were mostly of genera common in the Coal-measures, though of different species. Among them there are *Calamites* and *Lepidodendron*, *Walchia*, *Chondrites*, *Ullmania*, *Cardiocarpon*, *Alethopteris*, *Sphenopteris*, *Neuropteris*, and many fragments of undetermined coniferous wood. This, however, forms no perfectly conclusive proof of the lacustrine origin of the strata, though it is not unlikely that land-plants, drifted by rivers, should have been water-logged and buried in the sediments of lakes.

The evidence derived from Reptilian remains more strongly points in the same direction. First we have the Labyrinthodont Amphibian, *Dasyceps Bucklandi*, from the Permian sandstones near Kenilworth; next the footprints mentioned by Prof. Harkness in the red sandstones of the Vale of Eden; and again, the numerous footprints in the sandstones of Corncockle Moor, in Dumfriesshire, long ago described by Sir William Jardine. All of these prints indicate that the Amphibia

were accustomed to walk on damp surfaces of sand or mud open to the air, and the impressions left by their feet were afterward dried in the sun, before the waters flooded anew, overspread them with layers of sediment, in a manner that now annually takes place during the variations of the seasons on the broad flats of the Great Salt Lake of Utah and in other salt lakes. The occurrence of pseudomorphs of crystals of salt in the Permian beds of the Vale of Eden also helps to this conclusion, together with ripple-marks, sun-cracks, and rain-pittings, impressed on the beds. Crystals of common salt were not likely to have been deposited in an open sea, for, to form such crystals, concentration of chloride of sodium by evaporation is necessary. Deposits of gypsum, common in the Permian marls, could also only have been formed in inland waters by concentration, or on occasional surfaces of mud exposed to the sun and air, for no reasonable explanation can be offered of a process by means of which sulphate of lime can be deposited amid common mechanical sediments at the bottom of an open sea.

The question now arises how to account for the formation of the bands of magnesian limestone, sparingly intermingled with the red marls and sandstones of Lancashire and the Vale of Eden, and of that more important limestone district in the eastern half of the north of England, forming a long escarpment between Tynemouth and Nottingham. In these we have a true but restricted marine fauna, intermingled, however, with the relics of Amphibian and terrestrial life.

Let us broadly compare the marine life of the preceding epoch, that of the Carboniferous Limestone series, with the fossils of the Magnesian Limestone. The marine fauna of the Carboniferous Limestone of Britain contains about 1,500 species, most of which are mollusca (869), corals (124), echinodermata, crustacea (149), and fish (203). The Permian fauna feebly resembles that of the Carboniferous epoch, but, instead of the vast assemblage of many kinds of life found in the latter, the Magnesian Limestone of England only holds nine genera and 21 species of Brachiopoda, 16 genera and 31 species of Lamellibranchiata, 11 genera and 26 species of Gasteropoda, one Pteropod (*Theca*), and one Cephalopod (*Nautilus*). The whole comprises only 38 genera and 80 species, and all of these are dwarfed in size when compared with their Carboniferous congeners, when such there are.

I cannot easily account for this poverty of numbers and dwarfing of the forms, except on the hypothesis that the waters in which they lived were uncongenial to a true ocean fauna; and in this respect the general assemblage may be compared to the still more restricted marine faunas of the Caspian Sea and the Sea of Aral, or rather to that, a little more numerous and partly fossil, of the great Aralo-Caspian area of inland drainage, at a time when these inland brackish lakes formed part of a much larger body of water. Some of the fish of the Marl-slate have strong generic affinities with those of Carboniferous

age, a number of which undoubtedly penetrated into the shallow estuarine lakes and salt lagoons of that period. Associated with the Permian mollusca we find the Labyrinthodont Amphibian *Lepidotosaurus Duffii*, together with *Proterosaurus Speneri* and *P. Huxleyi*, both of which were true Lacertilian land reptiles.

Besides the poverty of species and the small size of the Mollusca of the true Magnesian Limestone, the chemical composition of these strata seems to afford strong hints that they were formed in an inland salt lake, the sediments of which were partly deposited through the effect of solar evaporation. Broadly stated, the rock may be said to consist of a mixture of carbonate of lime and carbonate of magnesia in proportions more or less equal, mingled with a little silicious sand mechanically deposited. The solid dolomite still contains "about one-fifth per cent. of salts soluble in water, consisting of chlorides of sodium, magnesium, potassium, and calcium, and sulphate of lime. These must have been produced at the same time as the dolomite, and caught in some of the solution then present, which is thus indicated to have been of a briny character" (Sorby). But, instead of such deposits having been formed in open sea-water, I submit that this evidence, joined to the facts previously stated, leads me to believe that our Permian dolomite was formed in an inland salt lake, in which carbonates of lime and magnesia might have been deposited simultaneously. This deposition was chiefly the result of concentration of solutions caused by evaporation, the presence of carbonate of lime in the rock being partly due to organic agency, or the life and death of the molluscs that inhabit the waters. I cannot understand how deposits of carbonate of magnesia could have taken place in an open sea, where necessarily lime and magnesia only exist in solution in very small quantities in a vast bulk of water. In the open sea, indeed, the formation of all beds of limestone is produced simply by the secretion of carbonate of lime effected by molluscs, corals, and other organic agents, and I know of no animal that uses carbonate of magnesia to make its bones.

The very lithological character of some of the strata helps to lead to the same conclusion, for, when weathered, they are seen to consist of a number of thin layers curiously bent and convoluted, and approximately fitting into each other, like sheets of paper crumpled together, conveying the impression that they are somewhat tufaceous in character, or almost stalagmitic, if it be possible to suppose such deposits being formed under water. The curious concretionary and radiating structures common in the limestone are probably also connected with the chemical deposition of the sediments.

Arguments of the same kind apply to the magnesian limestones of Lancashire and the Vale of Eden, and the miserable marine fauna in some of these beds also indicates inland *unhealthy waters*, while the deposits of bedded gypsum so common in the marls of the series show that the latter could not have been deposited in the sea.

Taking all these circumstances into account, the poverty of the marine fauna, the terrestrial lizards, the Amphibia, and the land-plants, I cannot resist the conclusion that the Permian rocks of England were deposited in a lake or in a series of great inland continental lakes, brackish or salt; and, if this be true, it will equally apply to some other regions of Europe.

The strata that succeed the Permian formations in the geological scale are those included in the word Trias, on the continent of Europe. These consist of three subdivisions: first and lowest, the Bunter sandstone; second, the Muschelkalk; and third, the Keuper marl, or *Marnes irisées*. The Bunter sandstone on the Continent consists chiefly of red sandstones, with interstratified beds of red marl and thin bands of limestone, sometimes magnesian. These form the *Grès bigarré* of France. In these strata, near Strasbourg, about thirty species of land-plants are known, chiefly ferns, Calamites, Cycads, and Coniferæ, and with them remains of fish are found and Labyrinthodont Amphibia. In the same series there occur Lamellibranchiate marine mollusca of the genera Trigonia, Mya, Mytilus, and Posidonia, so few in number that they suggest the idea, not of the sea, but of an inland salt lake, especially when taken in connection with the Labyrinthodont Amphibia and the terrestrial plants.

The Muschelkalk, next in the series, is essentially marine. A partial submergence took place, and a large and varied fauna of Mesozoic type occupied the area previously covered by the lake deposits of the Bunter sandstone.

Above this comes the Keuper series, with Gypsum and dolomite, land-plants, fish, and Labyrinthodont remains, and a few genera and species of marine shells, again suggesting the idea of a set of conditions very different from those that prevailed when the Muschelkalk was formed.

These strata, as a whole, are the geological equivalents of the New Red Sandstone and Marl of England, with this difference—that the Muschelkalk is entirely absent in our country, and we only possess the New Red Sandstone (Bunter) and the New Red Marl (Keuper).

The kind of arguments already applied to part of the Permian strata may, with equal force, be used in relation to the New Red Sandstone and Marl of England. I have for long held that our New Red Sandstone was deposited in an inland lake, probably salt, and that our New Red Marl was certainly formed in a salt lake. Pseudo-morphous crystals of salt are common throughout the whole formation, which, besides, contains two great beds of rock-salt, each 80 or 100 feet thick, which could only have been deposited in a lake that had no outflow, and from which all the water poured into it by the rivers of the country was entirely got rid of by evaporation induced by solar heat. It has been proved by analyses that all spring and river waters contain chloride of sodium and other salts in solution, and in such a lake, by

constant evaporation, salts must in time have become so concentrated that the water could hold no more in solution. This state of evaporation is now going on in the comparatively rainless areas of the Dead Sea, the Great Salt Lake of Utah, and in numerous lakes in Central Asia, though it is by no means asserted that in all of these positive deposition of salt has begun to take place. At length saline deposits began to be formed, which in the case of the New Red Marl consisted chiefly of common salt. This is impossible in an ordinary ocean, for the salt in solution cannot there be sufficiently concentrated to permit of deposition.

Gypsum and other salts contained in the red marl may also have been formed in like manner, and, as in the Permian and Old Red formations, I consider that the peroxide of iron which stains both salt and marl may have been carried into the lakes in solution as carbonate of iron, to be afterward deposited as a peroxide.

The remains of plants found in the British Keuper beds also speak of a surrounding land, while the Crocodile (*Stagonolepis*), the Dinosauria (land reptiles), Lizards (one of them a true land lizard, *Telerpeton*), and six supposed species of Labyrinthodont Amphibia, all tell the same tale of land. Rain-prints and sun-cracks are not wanting to help in the argument; and while the fishes yield no conclusive proof, the well-known bivalve crustacean *Estheria minuta* might have lived in any kind of area occupied by salt-water, while the small Marsupial Mammal *Microlestes antiquus* speaks conclusively of land.

Taken as a whole, it seems to me that the nearest conception we can form, of part of the old continent in which the Permian and New Red strata were deposited, is, that it physically resembled the great area of inland drainage of Central Asia, in which, from the Caspian 3,000 miles to the eastward, almost all the lakes are salt in a region comparatively rainless, and in which the area occupied by inland salt or brackish waters was formerly much more extensive than at present.

And now let me endeavor to sum up the whole of the argument. If, as I believe, the Old Red Sandstone was deposited in a lake or lakes; if the Coal-measures, as witnessed by the great river-beds, estuarine shoals, and wide-spread terrestrial vegetation, show proof of a continental origin; if the Permian strata were formed in inland salt or brackish waters, and if the New Red beds had a similar origin—then from the close of the Uppermost Silurian formation down to the influx of the Rhœtic Sea, which brought the Keuper Marl period to an end, there existed over the north of Europe, and in other lands besides, a great continent throughout all that time, one main feature of which was the abundance of Reptilian and Amphibian life. This old continent was probably comparable in extent to any of the largest continents of the present day, and perhaps comparable in the length of its duration to all the time represented by all the Mesozoic strata from the close of the Triassic epoch down to the latest strata of the

Chalk, and it may be even comprehending the additional time occupied in the formation of the Tertiary strata. But this latter part of the subject I propose to work out before long.

One other point remains. I have elsewhere attempted to prove, and the opinion is gaining ground in England, that this long continental epoch embraces at least two glacial episodes, as witnessed first by the bowlder-beds of the Old Red Sandstone of Scotland and the north of England, and secondly by the occurrence of similar deposits containing far-borne erratic blocks and ice-scratched stones, in a portion of that part of the Permian strata that is usually considered to represent the German Rothliegende. Should this be finally admitted, it may, on astronomical grounds, some day help us in the positive measurement of geological time.

Finally, let me rapidly pass in review what I think we know of later terrestrial, as opposed to marine epochs, in the British and neighboring areas of Europe. A wide-spred partial submergence brought the old continent to an end, and during the Liassic and Oolitic epoch (Jurassic) the Highlands of Scotland and other mountain-regions in the British Islands formed, with some other European Palæozoic rocks, groups of islands, round which, in warm seas, the Jurassic strata were deposited. These relics of an older continent, by deposition of newer strata and subsequent gradual upheaval, began to grow in extent, and at length formed the great continental area through which the mighty rivers flowed that deposited the strata of the Purbeck and Wealden series of England and the continent of Europe.

A larger submergence at length closed this broad local terrestrial epoch, and in those areas now occupied by Northern Europe (and much more besides), the sea, during the deposition of great part of the Chalk, attained a width and depth so great that probably only the tops of our British Palæozoic mountains stood above its level.

By subsequent elevation of the land, the fluvio-marine Eocene strata of Western Europe were formed, including in the term fluvio-marine the whole English series, embracing the London Clay, which as shown by its plant-remains was deposited at, or not far from, the mouth of a great river, which in size, and in the manner of the occurrence of some of these plants, may be compared to the Ganges. With this latter continent there came in from some land, unknown as yet, a great and new terrestrial mammalian fauna wonderfully different from that which preceded it in Mesozoic times, and from that day to this the greater part of Europe has been essentially a continent, and in a large sense all its terrestrial faunas have been of modern type.

One shadowy continent still remains unnamed, far older than the oldest of those previously spoken of. What and where was the land from which the thick and wide deposits that form the Silurian strata of Europe were derived? For all sedimentary strata, however thick and extended in area, represent the degradation of an equal amount

of older rocks wherewith to form them. Probably, like the American Laurentian rocks, that old land lay in the north, but whether or not, of this at all events I have more than a suspicion, that the red, so-called Cambrian, beds at the base of the Lower Silurian series indicate the last relics of the fresh waters of that lost continent, sparingly interstratified with gray marine beds, in which a few trilobites and other sea-forms have been found. Going back in time beyond this, all reasoning or detailed geological history becomes vague in the extreme. The faunas of the Cambrian, and especially of the Lower Silurian rocks, from their abundance and variety show that they are far removed from the beginning of life. Looking to the vanishing point in the past and the unknown future, well might Hutton declare that in all that the known rocks tell us "we find no vestige of a beginning —no trace of an end."—*Contemporary Review.*

MAGNETO-ELECTRIC ILLUMINATION.

By WILLIAM CROOKES, F. R. S.

THE progress made in electric illumination during its advance toward perfection has been several times recorded in the pages of this journal. In our first number, published nearly ten years ago, Dr. J. H. Gladstone gave a history of the early difficulties attending the introduction of the magneto-electric machine as a light-generator for light-house illumination. Two years subsequently, the present writer described Wilde's magneto-electric machine, and, after a further lapse of years, during which time no very important improvement in the industrial application of magneto-electricity has been recorded, another step in advance has been made which calls for detailed notice.

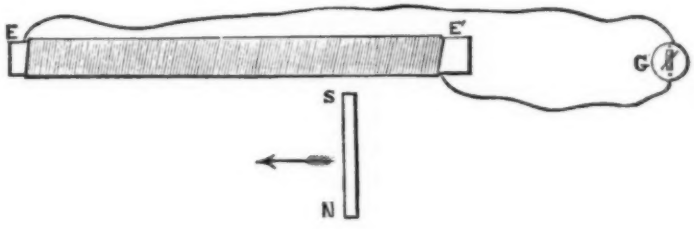
The chief difficulties in the employment of magneto-electric currents for industrial purposes have been their almost instantaneous character and the rapid alternation in their direction. The instrumental means necessary to seize hold of these rapidly-alternating waves, and convert them into a more or less continuous stream of force flowing in one direction, are necessarily of a delicate character, and are easily put out of adjustment. This is easily understood when it is remembered that, in the machine first tried by Mr. Holmes, the rubbing surfaces were worn away in ten or twenty minutes. The Berlioz machine required for its maximum of intensity 350 or 400 revolutions per minute, and the direction of the current is then reversed nearly 6,000 times per minute; here, however, the alternate currents are not brought into one. In the machine made by Mr. Wilde for the Commissioners of Northern Light-houses, the first armature is made to revolve about 2,500 times a minute, generating 5,000

waves of electricity. These alternate currents are converted into an intermittent current moving in one direction only by means of a commutator. The second armature revolves 1,800 times a minute, generating 3,600 alternately-opposed waves of electric force, which are picked up and sent in one direction by a commutator, as in the former case.

It is evident that when a good friction contact is to be kept between pieces of metal moving at these enormous velocities, the wear and tear is very great. For a long time, however, it was thought that these difficulties were inherent to the magneto-electric machine, until electricians found, first, that the almost instantaneous flash of the current could be considerably lengthened out, and then that the successive waves generated could be so produced as to flow in the same instead of in opposite directions.

These important desiderata are supplied in a magneto-electric machine of a novel form, invented by M. Gramme. The principle is not difficult to understand. Take a long bar of soft iron, E, E′, Fig. 1,

FIG. 1.

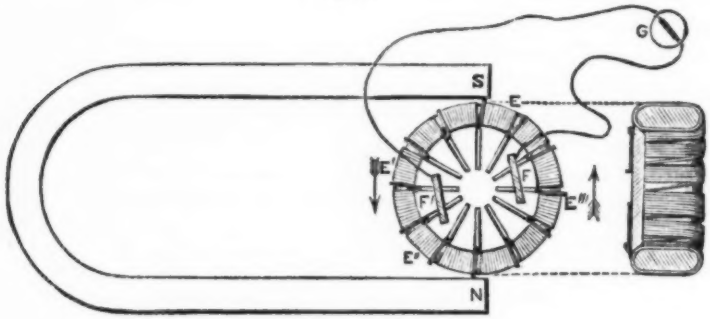


round which is coiled an insulated copper wire; to this bar, forming an electro-magnet, let a permanent magnet, S N, be presented, the south pole being nearest to the iron bar. Now move the permanent magnet in the direction of the arrow parallel with itself, with a uniform velocity, and always maintaining the same distance from the bar. The south pole of the permanent magnet will produce a north magnetic pole in the portion of the iron bar nearest to it; and the gradual displacement of this pole from one end to the other of the iron bar, caused by the motion of the magnet, will induce in the surrounding wire an electric current which may be rendered evident by the galvanometer, G. This current will not be instantaneous: it will continue to flow during the whole time the magnet is moving between the two ends, E E′, of the iron bar, and its time of duration may therefore be varied at pleasure.

This experiment shows that it may be possible, by proper arrangements, to realize a machine which will furnish a continuous current of electricity for as long as may be desired. We have only to imagine the electro-magnet, instead of being the straight bar shown in Fig. 1, bent into a circular form as at E, E′, E″, E‴, Fig. 2.

Submit this annular electro-magnet simultaneously to the influence of the two poles of the permanent horseshoe magnet, N S, and at the same time imagine it to revolve on its axis in the direction shown by the arrows.

FIG. 2.



The south pole, S, of the horseshoe magnet, will produce in that portion of the ring, E, which is near it, an electric current in a particular direction, as may be inferred from what we have said respecting the straight bar, Fig. 1. But the north pole, N, of the magnet, will likewise produce in the part of the ring which is in its neighborhood, E″, an electric current flowing in the opposite direction; and it is easily conceived that, in the two portions of the ring, E′, and E‴, which are in what may be called the mean position, there is no current at all. If, therefore, we wish to collect the two contrary currents produced simultaneously in the wire surrounding the electro-magnet, we have only to connect the wires at the mean position to two conductors by friction-contacts, F F′, when the current can be carried away to a galvanometer, G, and rendered sensible.

The principle of the arrangement being thus understood, the construction of the machine itself will be readily intelligible.

It consists of a permanent horseshoe magnet, S, O, N, Fig. 3, between the poles of which revolves an electro-magnet. This electro-magnet consists of a ring of soft iron, round which is wound an insulated conducting wire, presenting no solution of continuity. It may be conceived as being an ordinary straight electro-magnet bent round in a circle, and the two ends of the conducting wire soldered together to establish continuity.

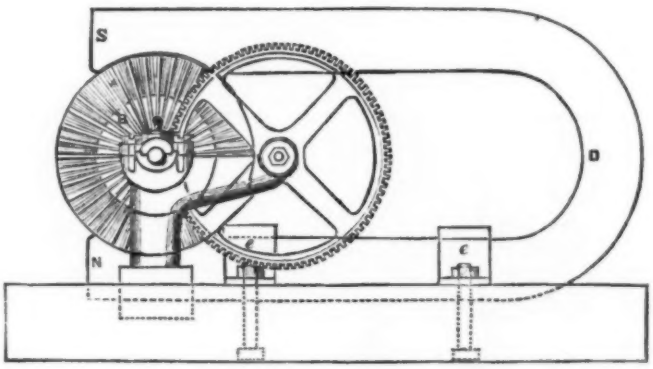
In Figs. 4 and 7 the electro-magnet is represented at A in section, while in Figs. 3 and 5 it is shown at A with the covering wire on it. It revolves round its axis on an axle to which movement is communicated either by means of belting, or with toothed gearing, shown in Figs. 3 and 4, worked by a handle, M.

The current is generated and collected in the following way: The wire surrounding the electro-magnet is, as we have said, continuous, but it is disposed in 40 sections or elements, each consisting, say, of

100 turns. The outer end of the coil of one section forms the commencement of the first coil of the next section, and so on. The whole of the wire is therefore divided into 40 equal sections, being, however, continuous throughout.

To understand better how an uninterrupted current is produced, let us imagine a line to be drawn equatorially, or perpendicular to the lines of force between the poles of the horseshoe magnet, and dividing the ring armature into two parts; suppose, likewise, that to the two ends of one of the 40 coils two wires are soldered, the other ends of which are attached to a galvanometer. Now let the ring be intermittently revolved in one direction, so as to give to the said coil a succes-

Fig. 2



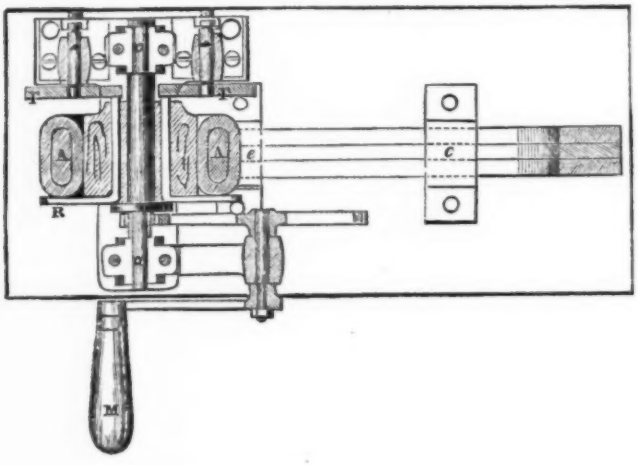
sion of movements of about 10 degrees, stopping each time to permit the galvanometer-needle to resume its normal position. It will then be seen that the whole time the coil is above the equatorial line the galvanometer-needle will be urged in the same direction, and the currents may be called *positive*. But, as soon as the said coil crosses the equatorial position, the currents generated in it will be *negative*, and in the opposite direction to what they were at the other half of the circle. This experiment shows that a reversal of the direction of movement carries with it a reversal of the direction of the current.

From this insight into what is produced in one of the sections, the general phenomena produced by the whole circle of coils are easily understood. The 20 sections which are on one side of the equatorial position are the source of positive currents; these may be of unequal intensity among themselves, but, for a uniform velocity of rotation, their sum is evidently constant; for, as one coil crosses the equatorial line from north to south, an opposite one comes up from south to north to take its place. On the other hand, the 20 sections which are on the other side of the equatorial line are the seat of negative currents, the sum of whose intensities is likewise constant, and equal to that of the positive currents.

Thus the revolving armature presents two groups of coils, generating two equal but opposite streams of electric force. The wire being unbroken, the currents neutralize each other, and there is no circulation. The result may be likened to what would be produced by taking two batteries, each of 20 cells, and connecting them in opposition by joining similar poles.

The problem now is to pick up these dormant currents and utilize their force. Its solution is apparent from the comparison we have just made. To collect the electric current from two batteries which are connected together in opposition, it is only necessary to fasten conducting wires to the two points of contact of similar poles, when the whole force of the batteries will flow along these wires. They were hitherto opposed, they now flow together, quantity-wise. M. Gramme, in the second portion of his invention, has adopted this artifice in an ingenious manner.

FIG. 4.



The various sections of the continuous electro-magnet are connected with radial pieces of copper shown at R in Figs. 3, 4, and 7, insulated one from the other, but coming very close. The termination of one coil of wire and the commencement of the adjacent coil are soldered to the same radial connector, of which, therefore, there are as many as there are coils. These radial connectors, on approaching the centre, are bent at right angles, as shown at R, Figs. 4 and 7, and pass through to the other side, where their ends form an inner concentric circle, being still insulated one from the other.

The friction-pieces F (Figs. 4, 5, and 6), consisting of disks of copper, are pressed, by means of springs shown at *r* (Figs. 5 and 6), against the circle formed by the extremities of the conducting radii R, at two points which are accurately in the equatorial line; that is to say, at

the place where the equal and opposed currents generated in the upper and lower halves of the ring neutralize each other. Consequently the currents are collected and flow together along conducting wires, which are fastened to the friction-pieces F.

The perfect continuity of the current so obtained is secured by causing the friction-pieces F to touch simultaneously several of the radial conductors R; consequently the metallic circuit is never broken.

FIG. 5.

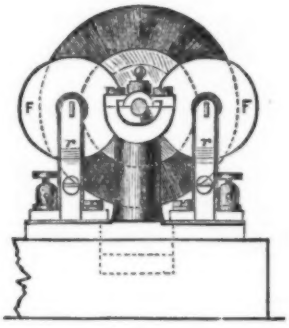
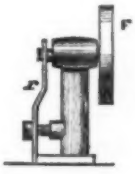
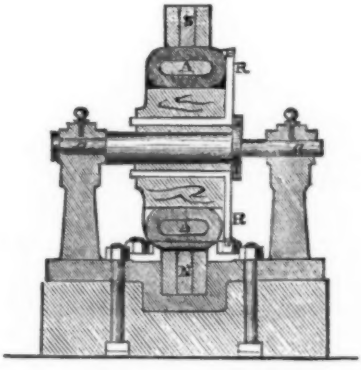


FIG. 6.



The effects produced by these machines vary with the rapidity of rotation. Experience shows that the electro-motive force is sensibly in proportion to the velocity; but it is probable that this force tends toward a limit, corresponding to a particular velocity, beyond which the electromotive force would remain constant, or even diminish. Moreover, the electromotive force is greater in proportion to the num-

FIG. 7.



ber of coils encircling the iron ring, but the relation between these two quantities has not yet been determined. The theoretical resistance of the machine should be one-fourth of the whole resistance of the wire wound round the ring armature; but the actual resistance is not so great, since each friction-disk always touches several radii, R, and

the resistance of the coils thus embraced by the friction-disk has to be subtracted from the resistance of the circuit.

The possibility of augmenting the strength of the current by increasing the dimensions of the machine is too obvious to need more than a passing allusion. The effects may also be increased by connecting together several such machines, as galvanic piles are connected, either for intensity or quantity. The quality of the current likewise differs according to the kind of wire surrounding the armature, a short thick wire producing effects of quantity, and a long thin wire, of intensity. It is also easy to see that two horseshoe magnets, instead of one, may be made to act on one ring armature; that is to say, it may be actuated by four poles instead of two, or even by a greater number; always having a friction-disk between each pair of poles. Moreover, the permanent horseshoe magnet may be replaced by electro-magnets, which can be excited by a portion of the current derived from the machine itself, according to the now well-known method. At the beginning of rotation the residual magnetism of these electro-magnets will induce a feeble current in the ring; one-half of this passes round the electro-magnets, the four poles of which react on the armature. Of the four friction-pieces, two carry half the current to excite the electro-magnets, and the machine rapidly attains the maximum effect. From conducting wires attached to the other two friction-pieces a powerful current is available.

A machine of this kind, containing two horseshoe electro-magnets, one for exciting and the other for the exterior current, and having round each pole 7 kilos. of copper wire 3 m.m. diameter, when worked by hand, decomposes water, and fuses 26 centims. of iron wire 9-10ths m.m. in diameter. However slowly the armature is rotated, the needle of a large galvanometer having the wire only once round is deflected, and the effects increase in intensity as the velocity of rotation increases, up to a maximum of 700 or 800 turns a minute, a velocity which is easily obtained when steam is employed.

Such a machine, giving an absolute continuous current of electric force by the mere turning of a wheel, is of value outside the physical laboratory. It is available—(1) for medical purposes; (2) for telegraphy; (3) for electro-plating, gilding, etc.; (4) for military purposes, signalling, explosions, etc.; (5) for chemical decompositions; and (6) for electric illumination.

A large machine, which has lately been exhibited in London, driven by a 2½-horse-power engine, produced a light equal to 8,000 candles; a copper wire about 1¼ m.m. in thickness, suspended between the poles, became instantly red-hot with a revolution of little over 300 in a minute. Larger machines are being made that will probably give a light equal to 25,000 candles.

This machine has lately been examined by the French *Société d'Encouragement*, and, in accordance with the recommendation of the

reporter, Count du Moncel, a prize of 3,000 francs has been awarded for it to M. Gramme; while the manager of the "Alliance Company," M. Joseph Van Malderen, who superintended its manufacture, has had awarded to him a gold medal. In his report, Count du Moncel says that a machine 1.25 metre in height, 0.8 metre long, and the same in width, driven by a 4-horse engine, gave a light equal to 900 carcel-lamps. It also heated to redness two juxtaposed copper wires 12 metres long and 0.7 m.m. diameter, and fused an iron wire 2.5 metres long and 1.3 m.m. thick.

The constancy of direction of the electric current generated by this machine is, however, not of so great an importance for the electric light as for other purposes for which it may be used. Indeed, the electric light is by many electricians thought to be superior when produced by a magneto-electric machine of the old form without any commutator. The alternate reversal of the currents of electricity produces no flickering or irregularity in the arc of light, as they occur far too quickly to be appreciated by the eye, while the rapid reversal of the direction causes the carbons to wear away with great regularity, thus enabling the point of light to be kept more easily in the focus.

For the electro-deposition of metals—copper, silver, etc.—constancy of direction of current is indispensable, and here the experiments show a marked superiority of the Gramme machine over other magneto-electric machines.

In the galvanoplastic works of M. Christofle, of Paris, where experiments have been going on for more than a year, it is found that the best machine hitherto known, when moved with a velocity of 2,400 revolutions per minute, only deposits 170 grammes of silver per hour; while a smaller Gramme machine moved with a velocity of 300 revolutions per minute deposits 200 grammes of silver per hour; the temperature of the annular armature not exceeding 50° C., with a velocity of 275 revolutions, no elevation of temperature is experienced. It will be easily comprehended how strongly this result, obtained with a speed of rotation eight times less than hitherto required, speaks in favor of M. Gramme's invention. Usually at M. Christofle's the circuits are arranged to deposit 600 grammes of silver per hour, and the manager of the factory finds that the deposition with this machine takes place with a regularity and constancy which leaves nothing to be desired, and which cannot be obtained by using any other source of electricity.

Recently, the electric light generated by a Gramme machine has been exhibited on the Victoria Tower of the Houses of Parliament. The machine is placed in the vaults of the House of Commons, near to the boilers, and is worked by a small engine, which was already there, and was convenient for the purpose. From the machine two copper wires, half an inch diameter, are led along the vaults to the base of the clock-tower, and thence upward to the signalling-point, a total length of nearly 900 feet, being about three times the distance that an

electric current has ever before been conducted for a similar purpose. The signalling apparatus is placed in a lantern five feet high, four feet wide, and having a semicircular glazed front, which projects from the lantern of the belfry on the north side of the tower, or that overlooking the Victoria Embankment. It consists—first, of a fixed table, in which is inserted a flat brass ring 16 inches diameter and one inch broad, which serves as a roller-path for the apparatus carrying the lamp and reflector; next, there is a circular revolving table, having bearings on the roller-path, and which is moved around a central pivot projecting from the fixed table, being actuated by a worm wheel and screw. By means of this arrangement the light can be directed horizontally from side to side through an arc of 180°. It could, of course, be made to sweep the whole of the horizon, but the position of the lantern with regard to the clock-tower is such as to enable the light to be seen through the range of a semicircle only. Upon the revolving table, and hinged to it at the front, is the elevating table, which has a screw adjustment to the rear by which the light can be raised or depressed, being capable of vertical training through an arc of 25°. On the elevator is placed the lamp-table, upon which again is a sliding platform, on which the lamps themselves stand. There are two lamps, which are in use alternately, the carbon-points lasting but four hours, while the House frequently sits for ten.

The copper conductors terminate at the fixed part of the machine, and the method of carrying the current from them to the lamps is very ingenious, the moving parts of the apparatus forming in themselves conductors. The negative conductor is placed in metallic contact with one hinge of the elevator-table through the centre-pin on which the table revolves, and the positive conductor with the other hinge by means of the brass roller-path. The currents from those points are conducted to the lamp-table, and thence through the traversing platform to the lamps, metallic contact being obtained throughout the whole circuit by means of flat springs moving over flat surfaces. The changing of the lamps is effected, without any appreciable break of continuity in the light, by means of the traversing platform on which they stand, and which has a sliding motion from side to side. When the carbon-points in one lamp are nearly consumed, the traverser is quickly shifted from right to left, or *vice versa*, as may be necessary. The break of contact is but momentary, and only exists during the time required to move the traverser rapidly through a space of six inches. The light will not become extinct during that period, as there is not sufficient time to allow the incandescence of the carbon to entirely subside. The springs under the lamp thrown out of use are by this action removed from the metal plate in the lamp-table, and the springs under the fresh lamp are brought into contact, and the light is at once produced anew.

The intensifying apparatus at present in use is a holophole lent by

Messrs. Chance, and through which the rays are sent in parallel lines. It is 21 inches in diameter, and is composed of lenses, surrounded by annular prisms, the centre part refracting the rays and the outer rings reflecting them. Should the electric light be adopted, a special lens will be constructed, by means of which the rays will be diffused through an arc of 180°, instead of being sent in one direction only. The cost of this electric light is at present estimated at 10*d.* per hour.

It may be of interest if we consider some matters of scientific interest in connection with this machine. In the first place, it possesses an enormous advantage over the voltaic battery in the absolute constancy of the current so long as the velocity of rotation is uniform. In an experiment carried on for eight hours with one of the first machines constructed, the deviation of the needle of a galvanometer was absolutely invariable. Again, a voltaic battery is a complicated piece of apparatus; for each element consists of four separate solid pieces (the outer cell, the porous cell, the positive and the negative element) and two liquids, while in most experiments a considerable number of batteries is required. From this multiplicity of parts a voltaic battery is subject to many accidental derangements, which are likely to weaken if not destroy its power. With the magneto-electric machine there is no complication. All the parts are solidly connected together, and no special care is required.

It must also be remembered that a powerful voltaic battery costs almost as much when it is at rest as when in action. The magneto-electric machine, on the contrary, costs nothing when it is not producing an external current. This may be understood in two senses. It is, of course, evident that, when no current is required, the rotation of the machine may be stopped; but it is a remarkable fact that, even when rotation of the armature is still going on, no mechanical force is expended except that necessary to overcome friction, provided the exterior current does not flow. To understand this, let us examine a little more closely into the working of the machine. In the first place, suppose the machine to be in rapid movement, and furnishing a current in an exterior circuit, it will be observed that the armature does not get hot; from this it may be concluded that all the mechanical force transmitted to the machine is converted into electricity, since none is changed to heat. In the next place, the machine continuing to revolve with the same speed, suppose the exterior circuit to be broken; still the machine does not rise in temperature, showing that in this case there is neither production of heat nor electricity, and consequently no waste of mechanical force. From the way in which the currents in the armature are generated, when there is no exterior circuit along which they can flow, they neutralize one another, and keep in such perfect equilibrium that there is absolutely no circulation, and consequently no heating.

If the Gramme machine is set in motion by a force just sufficient

to turn it with a definite velocity when the exterior current is flowing, and, if the outer circuit is suddenly broken, the machine is seen to acquire an increasing velocity, showing that the mechanical force applied to it, being no longer capable of going off as electricity, spends itself then in augmenting the velocity of the moving parts of the machine.

On the other hand, if the machine is kept at a certain speed of revolution while the outer circuit is broken, and the circuit is then suddenly closed, the speed instantly diminishes, showing that a portion of the force turning the machine changes into electricity.

These experiments show that, whether the machine be active or passive, there exists always a state of equilibrium between the expenditure of mechanical force and the production of electricity.—*Quarterly Journal of Science.*

THE STUDY OF SOCIOLOGY.

By HERBERT SPENCER.

XIV.—*Preparation in Biology.*

THE parable of the sower has its application to the progress of Science. Time after time new ideas are sown and do not germinate, or, having germinated, die for lack of fit environments, before they are at last sown under such conditions as to take root and flourish. Among other instances of this, one is supplied by the history of the truth here to be dwelt on—the dependence of Sociology on Biology. Even limiting the search to our own society, we may trace back this idea nearly three centuries. In the first book of Hooker's "Ecclesiastical Polity," it is enunciated as clearly as the state of knowledge in his age made possible—more clearly, indeed, than was to be expected in an age when science and scientific ways of thinking had advanced so little. Along with the general notion of natural law—along, too, with the admission that human actions, resulting as they do from desires guided by knowledge, also in a sense conform to law—there is a recognition of the fact that the formation of societies is determined by the attributes of individuals, and that the growth of a governmental organization follows from the natures of the men who have associated themselves the better to satisfy their needs. Entangled though this doctrine is with a theological doctrine, through the restraints of which it has to break, it is expressed with considerable clearness: there needs but better definition and further development to make it truly scientific.

Among reappearances of this thought in subsequent English writers, I will here name only one, which I happen to have observed in

"An Essay on the History of Civil Society," published a century ago by Dr. Adam Ferguson. In it the first part treats "Of the General Characteristics of Human Nature." Section I., pointing out the universality of the gregarious tendency, the dependence of this on certain affections and antagonisms, and the influences of memory, foresight, language, and communicativeness, alleges that "these facts must be admitted as the foundation of all our reasoning relative to man." Though the way in which social phenomena arise out of the phenomena of individual human nature is seen in but a general and vague way, yet it is seen—there is a conception of causal relation.

Before this conception could assume a definite form, it was necessary both that scientific knowledge should become more comprehensive and precise, and that the scientific spirit should be strengthened. To M. Comte, living when these conditions were fulfilled, is due the credit of having set forth with comparative definiteness the connection between the Science of Life and the Science of Society. He saw clearly that the facts presented by masses of associated men are facts of the same order as those presented by groups of gregarious creatures of inferior kinds; and that in the one case, as in the other, the individuals must be studied before the assemblages can be understood. He therefore placed Biology before Sociology in his classification of the sciences. Biological preparation for sociological study he regarded as needful, not only for the reason that the phenomena of corporate life, arising out of the phenomena of individual life, can be rightly coördinated only after the phenomena of individual life have been rightly coördinated, but also for the reason that the methods of inquiry which Biology uses are methods to be used by Sociology. In various ways, which it would take too much space here to specify, he exhibits this dependence very satisfactorily. It may, indeed, be contended that certain of his other beliefs prevented him from seeing all the implications of this dependence. When, for instance, he speaks of "the intellectual anarchy which is the main source of our moral anarchy"—when he thus discloses the faith pervading his "Course of Positive Philosophy," that true theory would bring right practice—it becomes clear that the relation between the attributes of citizens and the phenomena of societies is incorrectly seen by him: the relation is far too deep a one to be changed by mere change of ideas. Again, denying, as he did, the indefinite modifiability of species, he almost ignored one of the cardinal truths which Biology yields to Sociology—a truth without which sociological interpretations must go wrong. Though he admits a certain modifiability of Man, both emotionally and intellectually, yet the dogma of the fixity of species, to which he adhered, kept his conceptions of individual and social change within limits much too specific. Hence arose, among other erroneous preconceptions, this serious one, that the different forms of society, presented by savage and civilized races all over the globe, are but differ-

ent stages in the evolution of one form: the truth being, rather, that social types, like types of individual organisms, do not form a series, but are classifiable only in divergent and redivergent groups. Nor did he arrive at that conception of the Social Science by which alone it becomes fully affiliated upon the simpler sciences—the conception of it as an account of the most complex forms of that continuous redistribution of matter and motion which is going on universally. Only when it is seen that the transformations passed through, during the growth, maturity, and decay of a society, conform to the same principles as do the transformations passed through by aggregates of all orders, inorganic and organic—only when it is seen that the process is in all cases similarly determined by forces, and is not scientifically interpreted until it is expressed in terms of those forces—only then is there reached the conception of Sociology as a science, in the complete meaning of the word.

Nevertheless, we must not overlook the greatness of the step made by M. Comte. His mode of contemplating the facts was truly philosophical. Containing, along with special views not to be admitted, many thoughts that are true as well as large and suggestive, the introductory chapters to his "Sociology" show a breadth and depth of conception beyond any previously reached. Apart from the tenability of his sociological doctrines, his way of conceiving social phenomena was much superior to all previous ways; and among other of its superiorities, was this recognition of the dependence of Sociology on Biology.

Here leaving the history of this idea, let us turn to the idea itself. There are two independent and equally-important ways in which these sciences are connected. In the first place, all social actions being determined by the actions of individuals, and all actions of individuals being vital actions that conform to the laws of life at large, a rational interpretation of all social actions implies knowledge of the laws of life. In the second place, a society as a whole, considered apart from its living units, presents phenomena of growth, structure, and function, like those of growth, structure, and function in an individual body; and these last are needful keys to the first. We will begin with this analogical connection.

Figures of speech, which very often mislead by conveying the notion of complete likeness where only distant analogy exists, occasionally mislead by making an actual correspondence seem a fancy. A metaphor, when used to express a real resemblance, raises a suspicion of mere imaginary resemblance, and so obscures the perception of intrinsic kinship. It is thus with the phrases "body politic," "political organization," and others, which tacitly liken a society to a living creature: they are assumed to be phrases having a certain convenience but expressing no fact—tending rather to foster a fiction.

And yet metaphors are here more than metaphors in the ordinary sense. They are devices of speech hit upon to suggest a truth at first dimly perceived, but which grows clearer the more carefully the evidence is examined. That there is a real analogy between an individual organism and a social organism becomes undeniable, when certain necessities determining structure are seen to govern them in common.

Mutual dependence of parts is that which initiates and guides organization of every kind. So long as, in a mass of living matter, all parts are alike, and all parts similarly live and grow without aid from one another, there is no organization: the undifferentiated aggregate of protoplasm thus characterized belongs to the lowest grade of living things. Without distinct faculties, and capable of but the feeblest movement, it cannot adjust itself to circumstances, and is at the mercy of environing destructive actions. The changes by which this structureless mass becomes a structured mass, having the characters and powers possessed by what we call an organism, are changes through which its parts lose their original likenesses, and do this while assuming the unlike kinds of activity for which their respective positions toward one another and surrounding things fit them. These differences of function, and consequent differences of structure, at first feebly marked, slight in degree, and few in kind, become, as organization progresses, definite and numerous; and in proportion as they do this the requirements are better met. Now, structural traits, expressible in the same language, distinguish lower and higher types of societies from one another; and distinguish the earlier stages of each society from the later. Primitive tribes show no established contrasts of parts. At first all men carry on the same kinds of activities, with no dependence on one another, or but occasional dependence. There is not even a settled chieftainship; and only in times of war is there a spontaneous and temporary subordination to those who show themselves the best leaders. From the small unformed social aggregates thus characterized, the progress is toward social aggregates of increased size, the parts of which acquire unlikenesses that become ever greater, more definite, and more multitudinous. The units of the society as it evolves fall into different orders of activities, determined by differences in their local conditions or their individual powers; and there slowly result permanent social structures, of which the primary ones become decided while they are being complicated by secondary ones, growing in their turns decided, and so on.

Even were this all, the analogy would be suggestive; but it is not all. These two metamorphoses have a cause in common. Beginning with an animal composed of like parts, severally living by and for themselves, on what condition only can there be established a change, such that one part comes to perform one kind of function, and another part another kind? Evidently each part can abandon that original state in which it fulfilled for itself all vital needs, and can assume a state in

which it fulfils in excess some single vital need, only if its other vital needs are fulfilled for it by other parts that have meanwhile undertaken other special activities. One portion of a living aggregate cannot devote itself exclusively to the respiratory function, and cease to get nutriment for itself, unless other portions, that have become exclusively occupied in absorbing nutriment, give it a due supply. That is to say, there must be exchange of services. Organization in an individual creature is made possible only by dependence of each part on all, and of all on each. Now, this is obviously true also of social organization. A member of a primitive society cannot devote himself to an order of activity which satisfies one only of his personal wants, thus ceasing the activities required for satisfying his other personal wants, unless those, for whose benefit he carries on his special activity in excess, supply him with the benefits of their special activities. If he makes weapons instead of continuing a hunter, he must be supplied with the produce of the chase on condition that the hunters are supplied with his weapons. If he becomes a cultivator of the soil, no longer defending himself, then he must be defended by those who have become specialized defenders. That is to say, mutual dependence of parts is essential for the commencement and advance of social organization, as it is for the commencement and advance of individual organization.

Even were there no more to be pointed out, it would be clear enough that we are not here dealing with a figurative resemblance, but with a fundamental parallelism in principles of structure. We have but just begun to explore the analogy, however. The further we inquire, the closer we find it to be. For what, let us ask, is implied by mutual dependence—by exchange of services? There is implied some mode of communication between mutually-dependent parts. Parts that perform functions for one another's benefit must have appliances for conveying to one another the products of their respective functions, or for giving to one another the benefits (when these are not material products) which their respective functions achieve. And obviously, in proportion as the organization becomes high, the appliances for carrying on the intercourse must become involved. This we find to hold in both cases. In the lowest types of individual organisms, the exchange of services between the slightly-differentiated parts is effected in a slow, vague, inefficient way, by an irregular diffusion of the nutrient matters jointly elaborated, and by an irregular propagation of feeble stimuli, causing a rude coördination in the actions of the parts. It is thus, also, with small and simple social aggregates. No definite arrangements for interchanging services exist, but only indefinite ones. Barter of products—food, skins, weapons, or what not—takes place irregularly between individual producers and consumers throughout the whole social body: there is no trading or distributing system, as, in the rudimentary animal, there is no vascular system. So, too, the social organism of low type, like the individual organism

of low type, has no appliances for combining the actions of its remoter parts. When coöperation of them against an enemy is called for, there is nothing but the spread of an alarm from man to man throughout the scattered population; just as, in an undeveloped kind of animal, there is merely a slow, undirected diffusion of stimulus from one point to all others. In either case, the evolution of a larger, more complex, more active organism, implies an increasingly-efficient set of agencies for conveying from part to part the material products of the respective parts, and an increasingly-efficient set of agencies for making the parts coöperate, so that the times and amounts of their activities may be kept in fit relations. And this is what we find. In the individual organism, as it advances to a high structure, no matter of what class, there arises an elaborate system of channels through which the common stock of nutritive matters (here added to by absorption, there changed by secretion, in this place purified by excretion, and in another modified by exchange of gases) is distributed throughout the body for the feeding of the various parts, severally occupied in their special actions; while in the social organism, as it advances to a high structure, no matter of what political type, there develops an extensive and complicated trading organization for the distribution of commodities, which, sending its heterogeneous currents through the kingdom by channels that end in retailers' shops, brings within reach of each citizen the necessaries and luxuries that have been produced by others, while he has been producing his commodity or small part of a commodity, or performing some other function or small part of a function, beneficial to the rest. Similarly, development of the individual organism, be its class what it may, is always accompanied by development of a nervous system which renders the combined actions of the parts prompt and duly proportioned, so making possible the adjustments required for meeting the varying contingencies; while along with development of the social organism there always goes development of directive centres, general and local, with established arrangements for interchanging information and instigation, serving to adjust the rates and kinds of activities going on in different parts.

Now, if there exists this fundamental kinship, there can be no rational apprehension of the truths of Sociology until there has been reached a rational apprehension of the truths of Biology. The services of the two sciences are, indeed, reciprocal. We have but to glance back at its progress, to see that Biology owes the cardinal idea, on which we have been dwelling, to Sociology; and that, having derived from Sociology this explanation of development, it gives it back to Sociology greatly increased in definiteness, enriched by multitudinous illustrations, and fit for extension in new directions. The luminous conception first enunciated by one whom we may claim as our countryman by blood, though French by birth, M. Milne-Edwards—the conception of "the physiological division of labor"—obviously origi-

nates from the generalization previously reached in Political Economy. Recognition of the advantages gained by a society when different groups of its members devote themselves to different industries, for which they acquire special aptitudes and surround themselves with special facilities, led to recognition of the advantages which an individual organism gains when parts of it, originally alike and having like activities, divide these activities among them; so that each, taking a special kind of activity, acquires a special fitness for it. But now note that, when carried from Sociology to Biology, this conception was forthwith greatly expanded. Instead of being limited to the functions included in nutrition, it was found applicable to all functions whatever. It turned out that the arrangements of the entire organism, and not of the viscera alone, conform to this fundamental principle—even the differences arising among the limbs, originally alike, were soon to be interpretable by it. And then mark that the idea, thus developed into an all-embracing truth in Biology, comes back to Sociology ready to be for it, too, an all-embracing truth. For it now becomes manifest that not to industrial arrangements only does the principle of the division of labor apply, but to social arrangements in general. The progress of organization, from that first step by which there arose a controlling chief, partially distinguished by his actions from those controlled, has been everywhere the same. Be it in the growth of a regulative class more or less marked off from classes regulated—be it in the partings of this regulative class into political, ecclesiastical, etc.—be it in those distinctions of duties within each class which are signified by gradations of rank—we may trace everywhere that fundamental law shown us by industrial organization. And, when we have once adequately grasped this truth which Biology borrows from Sociology and returns with vast interest, the aggregate of phenomena which a society at any moment presents, as well as the series of developmental changes through which it has risen to them, become suddenly illuminated, and the *rationale* comparatively clear.

After a recognition of this fundamental kinship there can be no difficulty in seeing how important, as an introduction to the study of social life, is a familiarization with the truths of individual life. For individual life, while showing us this division of labor, this exchange of services, in many and varied ways, shows it in ways easily traced; because the structures and functions are presented in directly-perceivable forms. And only when multitudinous biological examples have stamped on the mind the conception of a growing interdependence that goes along with a growing specialization, and have thus induced a habit of thought, will its sociological applications be duly appreciated.

Turn we now from the indirect influence which Biology exerts on Sociology, by supplying it with rational conceptions of social develop-

ment and organization, to the direct influences it exerts by furnishing an adequate theory of the social unit—Man. For, while Biology is mediately connected with Sociology by a certain parallelism between the groups of phenomena they deal with, it is immediately connected with Sociology by having within its limits this creature whose properties originate social evolution. The human being is at once the terminal problem of Biology and the initial factor of Sociology.

If Man were uniform and unchangeable, so that those attributes of him which lead to social phenomena could be learned and dealt with as constant, it would not much concern the sociologist to make himself master of other biological truths than those cardinal ones above dwelt upon. But, since, in common with every other creature, Man is modifiable—since his modifications, like those of every other creature, are ultimately determined by surrounding conditions—and since surrounding conditions are in part constituted by social arrangements—it becomes requisite that the sociologist should acquaint himself with the laws of modification to which organized beings in general conform. Unless he does this he must continually err, both in thought and deed. As thinker, he will fail to understand the continual action and reaction of institutions and character, each slowly modifying the other through successive generations. As actor, his furtherance of this or that public policy, being unguided by a true theory of the effects wrought on citizens, will probably be mischievous rather than beneficial; since there are more ways of going wrong than of going right. How needful is enlightenment on this point will be seen, on remembering that scarcely anywhere is attention given to the modifications which a new agency, political or other, will produce in men's natures. Immediate influence on actions is alone contemplated, and the immeasurably more important influence on the bodies and minds of future generations is wholly ignored.

Yet the biological truths which should check this random political speculation and rash political action are conspicuous, and might, one would have thought, have been recognized by every one, even without special preparation in Biology. That faculties and powers of all orders, while they grow by exercise, dwindle when not used, and that alterations of nature descend to posterity, are facts continually thrust on men's attention, and more or less admitted by all. Though the evidence of heredity, when looked at in detail, seems obscure, because of the multitudinous differences of parents and of ancestors, which all take their varying shares in each new product, yet, when looked at in the mass, the evidence is overwhelming. Not to dwell on the countless proofs furnished by domesticated animals of many kinds as modified by breeders, the proofs furnished by the human races themselves are amply sufficient. That each variety of man goes on so reproducing itself that adjacent generations are nearly alike, however appreciable may sometimes be the divergence in a long series of gen-

erations, is undeniable. Chinese are recognizable as Chinese in whatever part of the globe we see them; every one assumes a black ancestry for any negro he meets; and no one doubts that the less-marked racial varieties have great degrees of persistence. On the other hand, it is unquestionable that the likenesses which the members of one human stock preserve, generation after generation, where the conditions of life remain constant, give place to unlikenesses that slowly increase in the course of centuries and thousands of years, if the members of that stock, spreading into different habitats, fall under different sets of conditions. If we assume the original unity of the human race, we have no alternative but to admit such divergences consequent on such causes; and, even if we do not assume this original unity, we have still, among the races classed by the community of their languages as Aryan, abundant proofs that the subjection to different modes of life produces, in course of ages, permanent bodily and mental differences: the Hindoo and the Englishman, the Greek and the Dutchman, have acquired undeniable contrasts of nature, physical and psychical, which can be ascribed to nothing but the continuous effects of circumstances, material, moral, social, on the activities, and therefore on the constitution. So that, as above said, one might have expected that biological training would scarcely be needed to impress men with these cardinal truths, all-important as elements in sociological conclusions.

As it is, however, we see that a deliberate study of Biology cannot be dispensed with. It is requisite that these scattered evidences, which but few citizens put together and think about, should be set before them in an orderly way; and that they should recognize in them the universal truths which living things at large exhibit. There requires a multiplicity of illustrations, many in their kinds, often repeated and dwelt upon. Only thus can there be produced an adequately-strong conviction that all organic beings are modifiable, that modifications are inheritable, and that therefore the remote issues of any new influence brought to bear on the members of a community must be serious.

To give a more definite and effective shape to this general inference, let me here comment on certain courses pursued by philanthropists and legislators, eager for immediate good results, but pursued without regard of these biological truths which, if borne in mind, would make them hesitate, if not desist.

Every species of creature goes on multiplying till it reaches the limit at which its mortality from all causes balances its fertility. Diminish its mortality, by removing or mitigating any one of these causes, and inevitably its numbers increase until mortality and fertility are again in equilibrium. However many injurious influences are taken away, the same thing holds, for the reason that the remaining injurious influences grow more intense. Either the pressure on the

means of subsistence becomes greater; or some enemy of the species, multiplying in proportion to the abundance of its prey, becomes more destructive; or some disease, encouraged by greater proximity, becomes more prevalent. This general truth, everywhere exemplified among inferior races of beings, holds of the human race. True, it is in this case variously traversed and obscured. By emigration, the limits against which population continually presses are partially evaded; by improvements in production, they are continually removed further away; and, along with increase of knowledge, there comes an avoidance of detrimental agencies. Still, these are but qualifications of an inevitable action and reaction.

Let us here glance at the relation between this general truth and the legislative measures adopted to ward off certain causes of death. Every individual eventually dies from inability to withstand some environing action. It may be a mechanical force that cannot be resisted by the strengths of his bodily structures; it may be a deleterious gas which, absorbed into his blood, so deranges the processes throughout his body as finally to overthrow their balance; or it may be, and most frequently is, an absorption of his bodily heat by surrounding things that is too great for his enfeebled functions to meet. In all cases, however, it is one, or some, of the many forces to which he is exposed, and in presence of which his vital activities have to be carried on. He may succumb early or late, according to the goodness of his structure and the incidents of his career. But, in the natural working of things, those having imperfect structures succumb before they have offspring, leaving those with fitter structures to produce the next generation. And, obviously, the working of this process is such that as many will continue to live and to reproduce as can do so under the conditions then existing: if the assemblage of influences becomes more difficult to withstand, a larger number of the feebler disappear early; if the assemblage of influences is made more favorable, by the removal of, or mitigation of, some unfavorable influence, there is an increase in the number of the feebler who survive and leave posterity. Hence two proximate results, conspiring to the same ultimate result. First, population increases at a greater rate than it would otherwise have done: so subjecting all persons to certain other destroying agencies in more intense forms. Second, by intermarriage of the feebler who now survive, with the stronger who would otherwise have alone survived, the general constitution is brought down to the level of strength required to meet these more favorable conditions. That is to say, there by-and-by arises a state of things under which a general decrease in the power of withstanding this mitigated destroying cause, and a general increase in the activity of other destroying causes, consequent on greater numbers, bring mortality and fertility into the same relation as before—there is a somewhat larger number of a somewhat weaker race.

There are further ways in which this process necessarily works a like general effect, however far it is carried. For, as fast as more and more detrimental agencies are removed or mitigated, and as fast as there goes on an increasing survival and propagation of those having delicately-balanced constitutions, there arise new destructive agencies. Let the average vitality be diminished by more effectually guarding the weak against adverse conditions, and inevitably there come fresh diseases. A general constitution, previously able to bear without derangement certain variations in atmospheric conditions, and certain degrees of other unfavorable actions, if lowered in tone, will become subject to new kinds of perturbation, and new causes of death. In illustration I need but refer to the many diseases from which civilized races suffer, but which were not known to the uncivilized. Nor is it only by such new causes of death that the rate of mortality, when decreased in one direction, increases in another. The very precautions against death are themselves, in some measure, new causes of death. Every further appliance for meeting an evil, every additional expenditure of effort, every extra tax to meet the cost of supervision, becomes a fresh obstacle to living. For, always in a society where population is pressing on the means of subsistence, and where the efforts required to fulfil vital needs are so great that they here and there cause premature death, the powers of producers cannot be further strained by calling on them to support a new class of non-producers, without, in some cases, increasing the wear and tear to a fatal extent. And, in proportion as this policy is carried further—in proportion as the enfeeblement of constitution is made greater, the required precautions multiplied, and the cost of maintaining these precautions augmented—it must happen that the increasing physiological expenditure thrown on these enfeebled constitutions must make them succumb so much the earlier: the mortality evaded in one shape must come round in another.

The clearest conception of the state brought about will be gained, by supposing the society thus produced to consist of old people. Age differs from maturity and youth in being less able to withstand influences that tend to derange the functions, as well as less able to bear the efforts needed to get the food, clothing, and shelter, by which resistance to these influences may be carried on; and, where no aid is received from the younger, this decreased strength and increased liability to derangement by incident forces make the life of age difficult and wearisome. Those who, though young, have weak constitutions, are much in the same position: their liabilities to derangement are similarly multiplied, and, where they have to support themselves, they are similarly overtaxed by the effort, relatively great to them and made greater by the maintaining of precautions. A society of enfeebled people, then, must lead a life like that led by a society of people who had outlived the vigor of maturity, and yet had none to

help them; and their life must also be like, in lacking that overflowing energy which, while it makes labors easy, makes enjoyments keen. In proportion as vigor declines, not only do the causes of pain multiply, while the tax on the energies becomes more trying, but the possibilities of pleasure decrease; many delights demanding, or accompanying, exertion are shut out; and others fail to raise the flagging spirits. So that, to sum up, lowering the average type of constitution to a level of strength *below that which meets without difficulty the ordinary strains, and perturbations, and dangers*, while it fails eventually to diminish the rate of mortality, makes life more a burden and less a gratification.

I am aware that this reasoning may be met by the criticism that, carried out rigorously, it would negative social ameliorations in general. Some, perhaps, will say that even those measures by which order is maintained might be opposed for the reason that there results from them a kind of men less capable of self-protection than would otherwise exist. And there will doubtless be suggested the corollary that no influences detrimental to health ought to be removed. I am not concerned to meet such criticisms, for the reason that I do not mean the conclusions above indicated to be taken without qualification. It is obvious enough that, up to a certain point, the removal of destructive causes leaves a balance of benefit. The simple fact, that, with a largely-augmented population, longevity is greater now than heretofore, goes far toward showing that, up to the time lived through by those who die in our day, there had been a decrease of the causes of mortality in some directions, greater than their increase in other directions. Though a considerable drawback may be suspected—though, on observing how few thoroughly-strong people we meet, and how prevalent are chronic ailments notwithstanding the care taken of health it may be inferred that bodily life now is lower in quality than it was, though greater in quantity—yet there has probably been gained a surplus of advantage. All I wish to show is, that there are limits to the good gained by a such a policy. It is supposed in the Legislature, and by the public at large, that, if, by measures taken, a certain number of deaths by disease have been prevented, so much pure benefit has been secured. But it is not so. In any case, there is a set-off from the benefit; and, if such measures are greatly multiplied, the deductions may eat up the benefit entirely, and leave an injury in its place. Where such measures ought to stop, is a question that may be left open. Here my purpose is simply to point out the way in which a far-reaching biological truth underlies rational conclusions in Sociology, and also to point out that formidable evils may arise from ignoring it.

Other evils, no less serious, are entailed by legislative actions and by actions of individuals, single and combined, which overlook or disregard a kindred biological truth. Besides an habitual neglect of the

fact that the quality of a society is physically lowered by the artificial preservation of its feeblest members, there is an habitual neglect of the fact that the quality of a society is lowered morally and intellectually, by the artificial preservation of those who are least able to take care of themselves.

If any one denies that children bear likenesses to their progenitors in character and capacity—if he holds that men whose parents and grandparents were habitual criminals have tendencies as good as those of men whose parents and grandparents were industrious and upright—he may consistently hold that it matters not from what families in a society the successive generations descend. He may think it just as well if the most active, and capable, and prudent, and conscientious people die without issue, while many children are left by the reckless and dishonest. But, whoever does not espouse so insane a proposition, must admit that social arrangements which retard the multiplication of the mentally-best, and facilitate the multiplication of the mentally-worst, must be extremely injurious.

For, if the unworthy are helped to increase by shielding them from that mortality which their unworthiness would naturally entail, the effect is to produce, generation after generation, a greater unworthiness. From decreased use of self-conserving faculties already deficient, there must result, in posterity, the smaller amounts of self-conserving faculties. The general law which we traced above, in its bodily applications, may be traced here in its mental applications. Removal of certain difficulties and dangers, which have to be met by intelligence and activity, is followed by a diminished ability to meet difficulties and dangers. Among children born to the more capable who marry with the less capable, thus artificially preserved, there is not simply a lower average power of self-preservation than would else have existed, but the incapacity reaches in some a greater extreme. Smaller difficulties and dangers become fatal in proportion as greater ones are warded off. Nor is this the whole mischief. For such members of a population as do not take care of themselves, but are taken care of by the rest, inevitably bring on the rest extra exertion, either in supplying them with the necessaries of life, or in maintaining over them the required supervision, or in both. That is to say, in addition to self-conservation and the conservation of their own offspring, the best, having to undertake the conservation of the worst, and of their offspring, are subject to an overdraw upon their energies. In some cases this stops them from marrying; in other cases it diminishes the numbers of their children; in other cases it causes inadequate feeding of their children; in other cases it brings their children to orphanhood—in every way tending to arrest the increase of the best, to deteriorate their constitutions, and to pull them down toward the level of the worst.

Fostering the good-for-nothing at the expense of the good is an extreme cruelty. It is a deliberate storing-up of miseries for future

generations. There is no greater curse to posterity than that of bequeathing them an increasing population of imbeciles and idlers and criminals. To aid the bad in multiplying, is, in effect, the same as maliciously providing for our descendants a multitude of enemies. It may be doubted whether the maudlin philanthropy which, looking only at immediate mitigations, persistently ignores remote results, does not inflict a greater total of misery than the extremest selfishness inflicts. Refusing to consider the remote influences of his incontinent generosity, the thoughtless giver stands but a degree above the drunkard who thinks only of to-day's pleasure and ignores to-morrow's pain, or the spendthrift who seeks immediate delights at the cost of ultimate poverty. In one respect, indeed, he is worse; since, while getting the present pleasure produced in giving pleasure, he leaves the future miseries to be borne by others—escaping them himself. And calling for still stronger reprobation is that scattering of money prompted by misinterpretation of the saying that "charity covers a multitude of sins." For, in the many whom this misinterpretation leads to believe that by large donations they can compound for evil deeds, we may trace an element of positive baseness—an effort to get a good place in another world, no matter at what injury to fellow-creatures.

How far the mentally-superior may, with a balance of benefit to society, shield the mentally-inferior from the evil results of their inferiority, is a question too involved to be here discussed at length. Doubtless it is in the order of things that parental affection, the regard of relatives, and the spontaneous sympathy of friends and even of strangers, should mitigate the pains which incapacity has to bear, and the penalties which unfit impulses bring round. Doubtless, in many cases the reactive influence of this sympathetic care which the better take of the worse, is morally beneficial, and in a degree compensates by good in one direction for evil in another. It may be fully admitted that individual altruism, left to itself, will work advantageously—wherever, at least, it does not go to the extent of helping the unworthy to multiply. But an unquestionable mischief is done by agencies which undertake in a wholesale way the preservation of good-for-nothings: putting a stop to that natural process of elimination by which otherwise society continually purifies itself. For not only by such agencies is this conservation of the worst and destruction of the best carried further than it would else be, but there is scarcely any of that compensating advantage which individual altruism implies. A mechanically-working State-apparatus, distributing money drawn from grumbling rate-payers, produces little or no moralizing effect on the capables to make up for multiplication of the incapables. Here, however, it is needless to dwell on the perplexing questions hence arising. My purpose is simply to show that a rational policy must recognize certain general truths of Biology, and to insist that only

when study of these general truths, as illustrated throughout the living world, has woven them into the conceptions of things, is there gained an adequately-strong conviction that enormous mischief must result from ignoring them.[1]

Biological truths and their corollaries, presented under these special forms as bases for sociological conclusions, are introductory to a more general biological truth including them—a general biological truth which underlies all rational legislation. I refer to the truth that every species of organism, including the human, is always adapting itself, both directly and indirectly, to its conditions of existence.

The actions which have produced every variety of man—the actions which have established in the Negro and the Hindoo constitutions that thrive in climates fatal to Europeans, and in the Fuegian a constitution enabling him to bear without clothing an inclemency almost too great for other races well clothed—the actions which have developed in the Tartar races nomadic habits that are almost insurmountable, while they have given to North-American Indians desires and aptitudes which, fitting them for a hunting-life, make a civilized life intolerable—the actions doing this, are also ever at work moulding citizens into correspondence with their circumstances. While the bodily natures of citizens are being fitted to the physical influences and industrial activities of their locality, their mental natures are being fitted to the structure of the society they live in. Though, as we have seen, there is always an approximate fitness of the social unit to its social aggregate, yet the fitness can never be more than approximate, and readjustment is always going on. Could a society remain unchanged, something like a permanent equilibrium between the nature of the individual and the nature of the society would presently be reached. But the type of each society is continually being modified by two causes—by growth, and by the actions, warlike or other, of adjacent societies. Increase in the bulk of a society inevitably leads to change of structure; as also does any alteration in the ratio of the predatory to the industrial activities. Hence continual social metamorphosis, involving continual alteration of the conditions under which the citizen lives, produces in him an adaptation of character which, tending toward completeness, is ever made incomplete by further social metamorphosis.

While, however, each society, and each successive phase of each society, presents conditions more or less special, to which the natures of citizens adapt themselves, there are certain general conditions

[1] Probably most readers will conclude that in this, and in the preceding Section, I am simply carrying out the views of Mr. Darwin in their applications to the human race. Under the circumstances, perhaps, I shall be excused for pointing out that the same beliefs, otherwise expressed, are contained in Chapters XXV. and XXVIII. of "Social Statics," published in December, 1850.

which, in every society, must be fulfilled to a considerable extent before it can hold together; and which must be fulfilled completely before social life can be complete. Each citizen has to carry on his activities in such ways as not to impede other citizens in the carrying on of their activities more than he is impeded by them. That any citizen may so behave as not to deduct from the aggregate welfare, it is needful that he shall perform such function, or share of function, as is of value equivalent at least to what he consumes; and it is further needful that, both in discharging his function and in pursuing his pleasure, he shall leave others similarly free to discharge their functions and to pursue their pleasures. Obviously, a society formed of units who cannot live without mutual hindrance, is one in which the happiness is of smaller amount than it is in a society formed of units who can live without mutual hindrance. And obviously the sum of happiness in such a society is still less than that in a society of which the units voluntarily aid one another.

Now, under one of its leading aspects, civilization is a process of developing in citizens a nature capable of fulfilling these all-essential conditions; and, neglecting their superfluities, laws and the appliances for enforcing them are expressions and embodiments of these all-essential conditions. On the one hand, those severe systems of slavery, and serfdom, and punishment for vagabondage, which characterized the less-developed social types, stand for the necessity that the social unit shall be self-supporting. On the other hand, the punishments for murder, assault, theft, etc., and the penalties on breach of contract, stand for the necessity that, in the course of the activities by which he supports himself, the citizen shall neither directly injure other citizens, nor shall injure them indirectly, by taking or intercepting the returns their activities bring. And it needs no detail to show that a fundamental trait in social progress is an increase of industrial energy, leading citizens to support themselves without being coerced in the harsh ways once general; that another fundamental trait is the progressive establishment of such a nature in citizens that, while pursuing their respective ends, they injure and impede one another in smaller degrees; and that a concomitant trait is the growth of governmental restraints which more effectually check the remaining aggressiveness. That is to say, while the course of civilization shows us a clearer recognition and better enforcement of these essential conditions, it also shows us a gradual moulding of humanity into correspondence with them.

Along with the proofs thus furnished that the biological law of adaptation, holding of all other species, holds of the human species, and that the change of nature undergone by the human species since societies began to develop, has been an adaptation of it to the conditions implied by harmonious social life, we receive the lesson, that the one thing needful is a rigorous maintenance of these conditions. While all see that the immediate function of our chief social institutions is

the securing of an orderly social life by maintaining these conditions, very few see that their further function, and in one sense more important function, is that of fitting men to fulfil these conditions spontaneously. The two functions are inseparable. From the biological laws we have been contemplating, it is, on the one hand, an inevitable corollary that, if these conditions are maintained, human nature will gradually adapt itself to them; while, on the other hand, it is an inevitable corollary that, by no other discipline than subjection to these conditions, can fitness to the social state be produced. Enforce these conditions, and adaptation to them will continue. Relax these conditions, and by so much there will be a cessation of the adaptive changes. Abolish these conditions, and, after the consequent social dissolution, there will commence (unless they are reëstablished) an adaptation to the conditions then resulting—those of savage life. These are conclusions from which there is no escape, if man is subject to the laws of life in common with living things in general.

It may, indeed, be rightly contended that, if those who are but little fitted to the social state are rigorously subjected to these conditions, evil will result; intolerable restraint, if it does not deform or destroy life, will be followed by violent reaction. We are taught by analogy, that greatly-changed conditions from which there is no escape fail to produce adaptation because they produce death. Men having constitutions fitted for one climate, cannot be fitted to an extremely-different climate by persistently living in it, because they do not survive, generation after generation. Such changes can be brought about only by slow spreadings of the race through intermediate regions having intermediate climates, to which successive generations are accustomed little by little. And doubtless the like holds mentally. The intellectual and emotional natures required for high civilization are not to be obtained by forcing on the completely-uncivilized the needful activities and restraints in unqualified forms: gradual decay and death, rather than adaptation, would result. But so long as a society's institutions are indigenous, no danger is to be apprehended from a too-strict maintenance of the conditions to the ideally-best social life; since there can exist neither the required appreciation of them nor the required appliances for enforcing them. Only in those abnormal cases where a race of one type is subject to a race of much-superior type, is this qualification pertinent. In our own case, as in the cases of all societies having populations approximately homogeneous in character, and having institutions evolved by that character, there may rightly be aimed at the greatest rigor possible. The merciful policy, no less than the just policy, is that of insisting that these all-essential requirements of self-support and non-aggression shall be conformed to—the just policy, because failing to protect the better or more-adapted natures against the worse or less-adapted; the merciful policy, because the pains accompanying the process of adaptation to the social state *must* be gone through, and it

is better that they should be gone through once than gone through twice, as they have to be when any relaxation of these conditions permits retrogression.

Thus, that which sundry precepts of the current religion embody—that which ethical systems, intuitive or utilitarian, equally urge, is also that which Biology, generalizing the laws of life at large, dictates. All further requirements are unimportant compared with this primary requirement, that each shall so live as neither to burden others nor to injure others. And all further appliances for influencing the actions and natures of men are unimportant compared with those serving to maintain and increase the conformity to this primary requirement. But, unhappily, legislators and philanthropists, busy with schemes which, instead of aiding adaptation, indirectly hinder it, give little attention to the enforcing and improving of those arrangements by which adaptation is effected.

And here, on behalf of the few who uphold this policy of natural discipline, let me emphatically repudiate the name of *laissez-faire* as applied to it, and emphatically condemn the counter-policy as involving a *laissez-faire* of the most vicious kind. While holding that, when the State leaves each citizen to get what good for himself he can, and to suffer what evil he brings on himself, such a let-alone policy is eventually beneficial, I contend that, when the State leaves him to bear the evils inflicted by other citizens, and can be induced to defend him only at a ruinous cost, such a let-alone policy is both immediately and remotely injurious. When a Legislature takes from the worthy the things they have labored for, that it may give to the unworthy the things they have not earned—when cause and consequence, joined in the order of Nature, are thus divorced by statesmen—then may properly come the suggestion, "Cease your interference." But when, in any way, direct or indirect, the unworthy deprive the worthy of their dues, or impede them in the quiet pursuit of their ends, then may properly come the demand, "Interfere promptly and effectually, and be in fact the protectors which you are in name." Our politicians and philanthropists, impatient with a salutary *laissez-faire*, tolerate and even defend a *laissez-faire* that is in the highest degree mischievous. Without hesitation, this regulative agency we call the Government takes from us some £100,000 a year to pay for art-teaching and to establish art-museums; while, in guarding us against robbers and murderers, it makes convictions difficult by demurring to the cost of necessary evidence: even the outlay for a plan, admitted by the tax-master, being refused by the Treasury! Is not this a disastrous *laissez-faire?* While millions are voted without a murmur for an expedition to rescue a meddling consul from a half-savage king, our Executive resists the spending of a few extra thousands to pay more judges: the result being not simply vast arrears and long delays, but immense injustices of other kinds—costs being run up in

cases which lawyers know will never be heard, and which, when brought into court, the over-burdened judges get rid of by appointing junior counsel as referees: an arrangement under which the suitors have not simply to pay over again all their agents, at extra rates, but have also to pay their judges.[1] Is not that, too, a flagitious *laissez-faire?* Though, in our solicitude for Negroes, we have been spending £50,000 a year to stop the East-African slave-trade, and failing to do it, yet only now are we providing protection for our own sailors against unscrupulous ship-owners—only now have sailors, betrayed into bad ships, got something more than the option of risking death by drowning or going to prison for breach of contract! Shall we not call that, also, a *laissez-faire* that is almost wicked in its indifference? At the same time that the imperativeness of teaching all children to write, and to spell, and to parse, and to know where Timbuctoo lies, is being agreed to with acclamation, and vast sums raised that these urgent needs may be met, it is not thought needful that citizens should be enabled to learn the laws they have to obey; and though these laws are so many commands which, on any rational theory, the Government issuing them ought to enforce, yet in a great mass of cases it does nothing when told that they have been broken, but leaves the injured to try and enforce them at their own risk, if they please. Is not that, again, a demoralizing *laissez-faire*—an encouragement to wrong-doing by a half-promise of impunity? Once more, what shall we say of the *laissez-faire* which cries out because the civil administration of justice costs us £800,000 a year—because to protect men's rights we annually spend half as much again as would build an iron-clad!—because to prevent fraud and enforce contracts we lay out each year two-thirds of the sum our largest distiller pays in spirit-duty!—what, I ask, shall we say of the *laissez-faire* which thus thinks it an extravagance that one-hundredth part of our national revenue should go in maintaining the vital condition to national well-being? Is not that a *laissez-faire* which we might be tempted to call insane, did not most sane people agree in it? And thus it is throughout. The policy of quiescence is adopted where active interference is all-essential; while time, and energy, and money, are absorbed in interfering with things that should be left to themselves. Those who condemn the let-alone policy in respect to matters which, to say the least, are not of vital importance, advocate or tolerate the let-alone policy in respect to vitally-important matters. Contemplated from the biological point of view, their course is doubly mischievous. They impede adaptation of human nature to the social state, both by what they do and by what they leave undone.

Neither the limits of this chapter, nor its purpose, permit exposition of the various other truths which Biology yields as data for

[1] And even then there are often ruinous delays. A barrister tells me that in a case in which he was himself the referee they had but six meetings in two years.

Sociology. Enough has been said in proof of that which was to be shown—the need for biological study as a preparation for grasping sociological truths.

The effect to be looked for from it is, that of giving strength and clearness to convictions otherwise feeble and vague. Sundry of the doctrines I have presented under their biological aspects are doctrines admitted in considerable degrees. Such acquaintance with the laws of life as they have gathered incidentally, lead many to suspect that appliances for preserving the physically-feeble bring results that are not wholly good. Others there are who occasionally get glimpses of evils caused by fostering the reckless and the stupid. But their suspicions and qualms fail to determine their conduct, because the *inevitableness* of the bad consequences has not been made adequately clear by the study of Biology at large. When countless illustrations have shown them that all strength, all faculty, all fitness, presented by every living thing, has arisen partly by a growth of each power consequent on exercise of it, and partly by the more frequent survival and greater multiplication of the better-endowed individuals, entailing gradual disappearance of the worse-endowed—when it is seen that all perfection, bodily and mental, has been achieved through this process, and that suspension of it must cause cessation of progress, while reversal of it would bring universal decay—when it is seen that the mischiefs entailed by disregard of these truths, though they may be slow, are certain—there comes a conviction that social policy must be conformed to them, and that to ignore them is madness.

Did not experience prepare one to find everywhere a degree of irrationality remarkable in beings who distinguish themselves as rational, one might have assumed that, before devising modes of dealing with citizens in their corporate relations, special attention would be given to the natures of these citizens individually considered, and by implication to the natures of living things at large. Put a carpenter into a blacksmith's shop, and set him to forge, to weld, to harden, to anneal, etc., and he will not need the blacksmith's jeers, to show him how foolish is the attempt to make and mend tools before he has learned the properties of iron. Let the carpenter challenge the blacksmith, who knows little about wood in general and nothing about particular kinds of wood, to do his work, and, unless the blacksmith declines to make himself a laughing-stock, he is pretty certain to saw askew, to choke up his plane, and presently to break his tools or cut his fingers. But, while every one sees the folly of supposing that wood or iron can be shaped and fitted, without an apprenticeship during which their ways of behaving are made familiar, no one sees any folly in undertaking to devise institutions, and to shape human nature in this way or that way, without a preliminary study of Man, and of Life in general as explaining Man's life. For simple functions we in-

sist on elaborate special preparations extending through years; while for the most complex function, to be adequately discharged not even by the wisest, we require no preparation!

How absurd are the prevailing conceptions about these matters, we shall see still more clearly on turning to consider that more special discipline which should precede the study of Sociology; namely, the study of Mental Science.

THE INTELLECTUAL POWERS OF BIRDS.

THE *Popular Science Review* for July contains some interesting but too brief remarks by Mr. Leith Adams on the "Mental Powers of Birds," which it is interesting to define specifically as distinguished from the mental powers of other animals of the higher order of sagacity. This we will briefly do. First, it would appear from Mr. Darwin's discussions—though Mr. Leith Adams hardly refers to them—that none of the lower orders of creatures have so keen an appreciation of beauty as many kinds of birds, and certainly that none turn this taste for beauty so deliberately to the purpose of social amusement. That great naturalist has described how some kinds of birds really celebrate festivities very closely approaching to our wedding *fêtes*, balls, and garden parties, in places carefully decorated and arranged by the birds for the purpose of social gatherings, and which are not used for their actual dwelling-places. The best evidence, says Mr. Darwin, of a taste for the beautiful "is afforded by the three genera of Australian bower-birds. . . . Their bowers where the sexes congregate and play strange antics" (at all stranger than our waltzes and quadrilles?) "are differently constructed; but, what most concerns us is, that they are decorated in a different manner by the different species. The satin bower-bird collects gayly-colored articles, such as the blue tail-feathers of paroquets, bleached bones and shells, which it sticks between the twigs, or arranges at the entrance. Mr. Gould found in one bower a neatly-worked stone tomahawk and a slip of blue cotton, evidently procured from a native encampment. These objects are continually rearranged and carried about by the birds while at play. The bower of the spotted bower-bird is beautifully lined with tall grasses, so disposed that the heads nearly meet, and the decorations are very profuse. Round stones are used to keep the grass-stems in their proper places, and to make divergent paths leading to the bower. The stones and shells are often brought from a great distance. The regent-bird, as described by Mr. Ramsay, ornaments its short bower with bleached land-shells belonging to five or six species, and 'with berries of various colors, blue, red, and black,

which give it, when fresh, a very pretty appearance. Besides these, there were several newly-picked leaves and young shoots of a pinkish color, the whole showing a decided taste for the beautiful.' Well may Mr. Gould say, 'These highly-decorated halls of assembly must be regarded as the most wonderful instances of bird-architecture yet discovered;' and the taste, we see, of the several species certainly differs." You could not have distincter evidence in a lady's *salon* carefully decorated with flowers, either of her taste for the beautiful, or of the deliberate subordination of that taste to social purposes, than we have here of the same qualities in birds. Mr. Leith Adams in his paper hardly refers, as we have already observed, to this remarkable class of facts at all, only pointing out that the obvious preference for gayly-colored plumage on the part of the females clearly implies a genuine taste for the beautiful in birds, which is, of course, true, but is not nearly as good evidence of a distinct intellectual development on this point as the elaborate decoration of their bowers by birds for festive purposes. The mere preference of gay colors may be unconscious and purely instinctive, but when a bird looks out for bleached land-shells and tall grasses to ornament its reception-room, and fetches round stones to "fix" the grasses in their proper place, and then uses the hall thus provided only for festive social purposes, you can hardly deny such birds either the powers or the tastes of landscape-gardeners and ball-givers. And we fancy this kind of deliberate taste for the beautiful, and the beautiful in subordination to social purposes, is confined among the lower animals to birds; and, as regards the social purposes, to a very few orders of birds. A great many birds seem to have more appreciation of beauty of color than almost any other class of animals, but only in a few species has it risen to the point of a really decorative social art. We may gather from this that in the bird the perception of harmony is of a very high kind, and this evidently applies to sound as well as color. No creatures utter sounds so full of beauty, or display such wonderful qualifications for imitating the beautiful sounds they hear. Must we not say, then, that the bird has, in more force than any other species of the lower animals, the perception of harmony in forms, colors, and sounds, and the further consciousness of the fascination such harmony has for its own species, and the enhancement it lends to social enjoyments?

Another great mental quality which birds seem to have in excess of other animals is a very fine calculation of distance, and this, too, in direct subordination to their own well-being. It has been shown again and again—and Mr. Leith Adams refers to some facts in support of it in this essay—that, as new weapons of offence are invented, many species of birds narrowly observe the range of the new bows or guns, and keep out of range, not even troubling themselves to go at all farther than is necessary to be out of range. Quite recently we have read, though we cannot verify the reference at present, of some birds

which adapted themselves within a few days to the increased range of the rifle, directly after they had learned its range for the first time, having been previously accustomed only to the fowling-piece, and kept just outside the two thousand yards' range, or whatever range it was, retaining their composure perfectly at that distance. We suppose the wonderful accuracy of the travelling birds in striking the exact point for which they are bound, of which Mr. Leith Adams gives us wonderful illustrations, is a still greater proof of the same power. Mr. Adams tells us of swifts which, after eight months' absence in the South—at a distance of some 1,800 or 1,900 miles—return not merely to the same region, but to the same nests which they had deserted, and that, too, year after year—the individuals having been marked so that there could be no mistake as to their identity, unless indeed there be such creatures as claimants to abandoned nests even in the ornithological world. Again, the delicate adaptation of the power of geometrical measurement to the welfare of its species seems to be shown by the weaver-bird of India, which hangs its "elaborately-constructed, purse-shaped nest" "from the tops of branches overhanging deep wells," in order to render it particularly difficult for enemies to get at the nest without running a great risk of falling into the well.

Again, none of the lower animals, except the monkey, seem to have so much imitative power, particularly in relation to sounds—the imitative power of monkeys has more of capacity in it for imitating gestures—as parrots, mocking-birds, ravens, and other tribes of birds. Curiously enough, this seems to be more or less a quality of tame, as distinguished from wild birds. At least, Mr. Leith Adams says that parrots, the cleverest of all these imitators when in captivity, "are not by any means given to copy the call-notes of other birds in their native woods," so that imitation would seem to be the channel into which their intellectual energy is apt to be directed, when they are robbed of their natural occupations. That is, we suppose, their perceptions being very acute, and their voice well developed, directly they are cut off from their usual occupations, they begin to imitate all they hear by way of exercising their latent faculties. That birds can go beyond mere imitation, and are to some extent accomplished actors, the evidence as to all those birds which, by false pretences of agitation, lure the trapper away from the vicinity of their nest, completely shows. Mr. Leith Adams bears witness to this, and tells besides the story of the trick played by the ruby-throated hummingbird of Canada, which, if captured, "feigns death by shutting its eyes and remaining quite motionless," and then suddenly makes a vigorous effort to escape. This shows not merely a dramatic gift, but a distinct purpose in the use of it. *Ruses* of a similar kind are, however, not unexampled in other animals and birds. Cats, for instance, constantly feign sleep, for the purpose of catching birds or mice more effectually.

On the whole, however, it may be safely said that birds seem to have much more capacity for perceiving beauty, much more gift for social enjoyment, a finer knowledge of distance and direction, and more power of vocal imitation, than any other order of animals of which we know any thing. On the other hand, they have less sense of power and sympathy than the dog, and therefore much less sense of responsibility to their superiors, whom they often love, but seldom serve. Perhaps we might generalize these mental qualifications by saying that birds are chiefly educated by perceptions, wonderfully accurate indeed, but still of things at a distance, of things at an almost telescopic range; that their rapidity of flight makes them creatures of *wide* experience, but not of *full* experience of any species but their own; and that, as a result, they cannot know men well enough to learn as much from men, as dogs, and cats, and elephants, and even other orders of creatures learn. Birds, in short, get bird's-eye views of the earth, and bird's-eye views, however instructive to those who have previously mastered the details carefully, do not exactly furnish a good basis for progressive knowledge. They obviously get a knowledge of geography, and, in some sense, of the air and its currents, such as no other creatures can have. They have an ear for music, and an eye for harmony of form and color, and probably of movement—for there are bird-dances which Taglioni would have despaired of imitating—such as no other member of the animal world possesses; and the perception of beauty, we know, depends on nothing so much as the *coup d'œil*, and this birds can always command. But they lose, by their great privilege of wings, that slow and sure experience of the ways of man which some less-gifted animals acquire. A swift which flies at the rate of 270 miles an hour, according to Mr. Leith Adams, clearly cannot have a brain to utilize an experience acquired at that rate in any but a very perfunctory way. Therefore, though birds have so strange a perception of beauty, which hardly needs close analysis, they are too fast, too migratory in their habits, to learn any thing which needs perfect fidelity and vigilance confined to a very narrow circle of facts. They are the musicians, and we might almost say the sensuous poets of the animal world; but musicians and sensuous poets do not conduce to progressive knowledge and ethical culture. Birds range too high and fly too fast for sympathy with man, and so it happens that their intellectual powers, remarkable and unique as they are in the animal world, never become so human and so almost spiritual as those of creatures which can only boast of very inferior powers.—*Spectator.*

HYPNOTISM IN ANIMALS.

By Prof. JOSEPH CZERMAK.[1]

TRANSLATED FROM THE GERMAN, BY CLARA HAMMOND.

GENTLEMEN: I propose in two lectures to bring to your notice a subject which, in very many respects, is one of great and increasing interest.

The physiological facts which I shall demonstrate and discuss, as they occur in various animals, are remarkably surprising. They will afford us opportunities for making deductions which are interesting in their historical relations, and they will also serve to demonstrate to us how man, uneducated in natural science, is deficient in judgment when he comes to view unfamiliar incidents of Nature. They will show us that such a man examines natural phenomena in a way which is certain to deceive him, by convincing him that he has observed events which in reality never occurred.

The obstinacy and lack of discernment which he thus brings to bear on his investigations are truly astonishing; and it is not surprising, therefore, that the intelligent inquirer into the operations of Nature should place little reliance on the testimony of highly-honorable persons whose minds are untrained to the work they have undertaken. Even when such persons are possessed of great culture—even perhaps in natural science—but are not infused with that spirit of exact investigation so necessary to the discovery of truth in Nature, we are justified in regarding their statements with hesitation and suspicion. Often, very often, we are obliged to listen to relations of unusual or dubious natural events, and cannot avoid feeling irritated at the assertions—which the speaker regards as putting an end to all argument—"I was there. I saw it all with my own eyes, and heard it with my own ears. What I report is actually true!"

The relator has really been present; he has seen and heard every thing of which he speaks; he is in real earnest, and he tells the truth; and yet what he reports has never taken place, and the real investigator of Nature is perfectly right in disregarding his testimony, while, at the same time, his truthfulness is not questioned.

This may strike you as paradoxical. It is so, however, only in appearance, for the discrepancy disappears when we come to make the discovery that it is the perception of the observer which is at fault, and that the eyes and ears have been correct, so far as their functions were concerned. The circumstance is what I call *an event viewed unequally.*

[1] These lectures were delivered by Professor Czermak (pronounced Tshermak) in the private physiological laboratory of the University of Leipsic, on the 24th and 25th of January, 1873.

In the want of discernment in which such an observer is placed, when investigating Nature, he regards the temporary coincidences and consequences of certain real events as in themselves real. He accepts these circumstances at once, and without thorough investigation, as having an intimate and direct relation with real events. He, therefore, forms a conception of something which is not real, and he reports as an actual occurrence that which, in the way he means, never in fact took place. Such a circumstance constitutes an event not thoroughly tested, or an incident unequally investigated, and, I believe, we are not merely logically justified, but morally forced, to distinguish, among events in the perception of Nature, a new and especial category, that of *events viewed unequally.* In this category are embraced circumstances which play a most extensive *rôle* in the history of the development of the human mind. Without the conception of this class of supposed incidents, we would never be capable of understanding and explaining certain obscure appearances and tendencies of the human mind, and the persistency with which they rise and maintain themselves as often as they are overthrown, and when they have scarcely even had time to disappear.

Nothing strengthens the mind like a habit of investigating natural events with thoroughness and strictness. Without this habit, credulity and superstition can neither be broken nor restrained.

We children of the nineteenth century are not a little proud of our civilization, culture, and enlightenment. And yet, if a comparison were made between the ruling mind of the middle ages and that which now reigns, no great progress would be perceived. In fact, we have no right to plume ourselves on the material development of our era, so long as certain tendencies of the mind remain as they were ages ago, and while we are no more capable, than we were then, of investigating natural events, so as to deduce the truth from them.

It would carry me too far from my subject if I were to give even a hasty glance at all those tendencies and false appearances which, so to say, calumniate our enlightened and cultivated life. It will suffice merely to mention the manias of table-turning, spirit-rapping, spiritual apparitions, animal magnetism, and clairvoyance. To-morrow, at the conclusion of the second lecture, I will give a more detailed account of these subjects, as they appear in the light of facts. In what I have said this morning, I wished principally to prepare your minds for the facts I am about to state, and for the proper consideration of certain apparently wonderful physical phenomena which, though partially known for some time, have received no scientific investigation, and which, therefore, have not been awarded their proper place in the domain of nervous physiology.

During the autumn of the past year, while sojourning in Bohemia, I made the acquaintance of a gentleman who, in the course of one of our scientific discussions, communicated to me the striking information

that he had not only seen others magnetize crawfish, but had himself succeeded in the attempt. On being asked for fuller particulars as to what he meant, the gentleman told me that the whole thing was uncommonly simple.

You hold the crawfish firmly in one hand, and with the other make magnetic strokes from the end of the animal toward the head. If, in the mean while, when making these passes in the given direction, and carefully avoiding any other movement, the tips of the fingers are placed at the animal's back, it forms an arch as the hand is withdrawn. Under this manipulation the crawfish, in a short time, becomes quiet, places itself on its head in a vertical position, using its feelers and the two claws, which are pushed inward, as a support. In this peculiar and unnatural position the animal remains motionless, until passes are again made in the opposite direction, beginning at the head, at which it begins to move once more, tries to lose its equilibrium, at last falls, and crawls away.

As my informant was known to be an intelligent man, and of a most credible, honorable character, of course I could entertain no doubt respecting the veracity of this simple, clear, though remarkable statement, and least of all could I have expressed such a doubt to him; but my knowledge of Nature led me to say to him that, although I placed the utmost belief in his communication, I was of the opinion that he had related to me an "event viewed unequally."

Indeed, that the crawfish placed itself on its head, and remained motionless in this position after having the passes made over it, was certainly an actual circumstance, inasmuch as he testified to it; but that the so-called "magnetic" strokes with the finger-tips, and the action of magnetizing, were the actual cause of the crawfish's condition, was, for me, in spite of his testimony, and without wishing to presume upon him, no real incident, that I could accept on faith and belief, or, above all, consider worthy of an earnest inspection; because this was in no way the object of his perception and examination.

I desired him to show me the experiment—not that I expected a demonstration, nor that I doubted his facts—but mainly because I had nothing better to do, and I thought I would be able to promise him on this occasion a clearer idea of moderate perceptions in Nature, as a slight service on my part, and show him, with an example, what an "event viewed unequally" was. No sooner said than done. The order was given to procure crawfish from a neighboring brook, and we soon had a basketful before us.

What then happened I will illustrate to you in the same way that we performed the experiment then, for I have here in this vessel a number of crawfish all ready. My friendly companion, sure of the result of his experiment, seized one of the animals and began his "magnetic" strokes, from the end toward the head, exactly as I am doing now. The crawfish, which at first resisted, gradually became calm;

and now, indeed, his crooked tail high in the air, he places himself on his head, and remains motionless, as if asleep, in this forced and unnatural position; while he finds his support in his feelers and two under claws.

It is really a surprising sight! While we then, as now, saw the conclusion of the experiment with satisfaction and interest, I, on my part, had seized an animal with the intention of endeavoring to place it on its head, without the magnetic strokes, and thereby to remove the reasonable thought of a secret "magnetic" influence contained in the strokes.

And see!—my crawfish, after in vain struggling in my firm grasp, actually stood just as motionless on its head as the one which my compainion had magnetized, and as this one here which I have placed before you on its head, without all that deceptive magnetism. And how was it with the opposite strokes, beginning from the head? My friend worked zealously with these strokes upon his crawfish, while I represented the opposite experiment. It lasted some time, until the crawfish began to move, and at last fell over and crawled away.

You see that my strokes here with this crawfish have so far no result, and I fear you will lose all patience. Indeed, let us confidently interrupt this opposite manipulation, and let us rather place the rest of the crawfish, without magnetism, on their heads, in order to confirm this striking circumstance again. The longer we wait before resuming the magnetic strokes from the head, the more sure we are at last to reap the benefit. It is the same with this as with the solemn request of a Catholic parish in Austria to their priest, which was, to send rain from heaven upon their parched fields, to which, however, the enlightened "Joseph," in order to postpone it a little, said: "Yes, willingly, children!—but not just yet, the barometer has been much too high for some time past!" Let us then follow the good advice of the wise pastor; you will see yourselves, if you wait, that gradually all the crawfish, standing motionless on their heads, move again of their own accord, without any mysterious manipulation! In regard to the influence of the other motion, it is nothing at all. We are able to act upon the altered nervous system of the crawfish by mechanical means, through the influence of a stream of air, through a sudden coolness or warmth, or through the natural disturbance previous to the awakening; that is, the restoration of the normal functional capacities.

You also see, gentlemen, our experiment then and now has terminated exactly as I predicted, and I hope that you will now be convinced, as my companion was, that the so-called "magnetizing" of the crawfish is an actual event; but, as I say, one "viewed unequally," and, *therefore, not one!* At the same time, the idea will become clear and distinct to you, which I have associated with the description of "events viewed unequally," and the reason that I have chosen this particular description, to demonstrate something which is not an event at all, will be apparent to you.

The only actual fact in the "magnetism" of the crawfish is the motionless state which follows the strokes in the air. While one considers this actual succession, without any examination, to be a mysterious connection of the "magnetic" influence, so one thinks this non-existing connection to be a real event, and decidedly true. Therefore, I call such events which never took place, none the less circumstances, but, in order to distinguish them from actual ones, I designate them as "viewed unequally." I do this in order to indicate the characteristic circumstance that, in the foundation, something of actuality exists, and thus gives them an appearance of reality. This immediately strikes the person whose judgment is not altogether exact, and can only be removed by a close examination and inspection. This last, however, is not the case with every one, and thus the great powers of reason and prudence which execute these events explain themselves, and also explain the immense *rôle* which they play in the history of human error.

In the so-called magnetizing of the crawfish, the only actual incident is the one already mentioned. This is simple enough, as the crawfish possesses the remarkable quality of being able to lose the normal excitation and power of acting belonging to its nervous system, and is also capable of supporting itself, when it is placed gently in some particular position, in spite of its former resistance. As to the magnetic strokes, they have certainly no significance.

That, however, the actual change of posture in the crawfish does not depend upon a mysterious magnetic fluid, which proceeds from the fingers and hands of the experimenter, is proved by the attempt in which the crawfish is not touched and held by the hand in any way. In this experiment the crawfish is held by a string, and that striking condition of immobility, which lasts some time and then disappears, is just as apparent in it as in the others.

I will place a loose string around the tail of this crawfish, without moving the animal, draw the ends lightly together, and hang the crawfish by means of it on this frame. You see how the animal, with its head downward, in vain strives to free itself from its unnatural position. This, however, does not last long. It becomes quiet, and finally hangs completely motionless, as though it had been held firmly in my hand. This continues until it sooner or later begins again to move of its own accord.

With a glass tube I will roll this second crawfish on its back; it endeavors to regain its proper position; but, in consequence of being prevented with the glass tube, it does not succeed. The animal's resistance is fruitless; the tube holds it firmly, and see! it now remains quiet on its back, and will sooner or later move again of its own accord.

Now, as in the former experiment, we can no longer speak of a magnetic influence, proceeding from the experimenter, but, neverthe-

less, in both cases, the crawfish remained motionless after its first resistance was made unsuccessful, by means of the tube and pure mechanical force. But crawfish, which crawl briskly in their course backward, often remain for some time motionless, a result which is caused by no visible circumstance. We thus learn that normal, unmolested crawfish can become motionless, just as well as the ones we experiment with, only the mysterious character of these experiments does not lose all its interest, for we see that the immobility which we occasion by our preparation cannot be prevented, while the crawfish which is not subjected to our manipulations becomes motionless through no demonstrable or extraordinary circumstance. Again, we see that the experimental crawfish become immobile, and remain so, notwithstanding that, in consequence of the unnatural positions in which they are placed, they are exposed to a powerful inducement to move, and cannot be quite determined as to the normal condition and degree of excitability of their nervous systems. The unmolested crawfish, however, experiences no such emotion.

Of the latter, which fall into a motionless state and remain so, two kinds may be seen. Either the crawfish is in a normal and wakeful condition, and does not move because it has no motive for doing so, and consequently does not wish to move, or else it cannot move because it is exhausted, or finds itself in a state of lethargy and sleep. In regard to our experimental animals there is no doubt, as already stated, that they are placed in positions in which they would move if they could, that is, if they were in a condition capable of working their nervous system.

And thus you see how, through a minute and scientific inspection, we have arrived at the fact that, instead of finding the actual circumstance by magnetizing the crawfish, the animals in winter and autumn, when their instinct is duller than at other seasons, possess the remarkable quality of losing the normal excitability of their nervous systems, even in the most forced positions; also that they are again able to maintain their equilibrium in spite of resistance made at first, after they have been held firmly a certain time.

I remember once seeing a like effect in hens which had been experimented upon in the same way. I had already known of this fact, but had never possessed the opportunity or occasion to give it a strict investigation. I therefore concluded to experiment upon the poultry-yard of my hospitable country-friend with whom I was then staying. Many of you, no doubt, have been told, or else know from your own experience, that wild, frightened hens which one has had great difficulty in catching and holding, are liable to become completely motionless as if enchanted by some magical spell, after being held with gentle force upon the floor or table where a chalk-line has been drawn the length of the beak or diagonally from each eye. Now, although this sounds very incredible, it is an actual fact and I will

endeavor to demonstrate it to you. Yet, I am obliged to say expressly beforehand that I cannot promise you this experiment will succeed, in consequence of this large assembly, the light, and the room, which, in spite of the quiet and attention, is not wholly free from noise. I have never performed this experiment under such circumstances, and therefore cannot say whether any disturbing influence would affect my hen.

I must call to your remembrance, for my own safety as a careful and circumspect experimenter, that we are making a new experiment, or, in fact, an old one under somewhat altered circumstances. Therefore we must be fully prepared to make a new discovery, which will probably undeceive us in no agreeable manner, if it robs us of the pleasure of confirming, now and here, the wonderful accounts relative to the condition in which a timid hen can be placed after such apparently insipid and senseless preparations.

(The lecturer caused one of his assistants to bring him a hen and hold it fast upon the table. This was done after much resistance and many cries from the frightened bird; then with his left hand he held the head and neck of the hen upon the table, and with his right hand drew a chalk-line, beginning from the end of the beak, on the flat surface, which was of a dark color. Left entirely free, the hen, though breathing heavily, remained entirely quiet upon the table; then, without moving, it allowed itself to be placed on its back, and remained in this unnatural position until the close of the lecture. It only awoke when the audience began to leave.)

When I performed this experiment for the first time and with the same result as you now see, I was for the moment dumb with astonishment, for the hen not only remained motionless in its unnatural and forced position, but did not make the slightest attempt to fly away or to move in any manner whatever when I endeavored to startle it. It was clear the hen had lost the entire normal functional capacities of its nervous system under the apparently indifferent and useless arrangement of the experiment, and had been placed in this remarkable condition as though by magic. This state is characterized by a greater or a less suspension of its intelligence or will.

But *nil admirari* is the first maxim of the moderate investigator of nature. We must now ascertain the actual connection of these phenomena, so as not to stand still at an "event viewed unequally," like old Athanasius Kircher, the celebrated *savant* and Jesuit from Fulda, who affirmed this mysterious result in one of his works which appeared in Rome about 1646, "*Ars magna lucis et umbræ*," as a positive corroboration of the immense imagination of hens. Kircher performed the experiment (which he called "*experimentum mirabile de imaginatione gallinæ*," and illustrated excellently with a fine woodcut) in the following way:

He first tied the hen's feet together with a narrow ribbon and laid

the animal on the ground, where after many cries and violent struggling it became quiet, "as if," he says, "despairing of escape through the fruitlessness of its motions, it gave itself up to the will of its conqueror." Then Kircher drew a chalk-line in a diagonal direction from one eye to the other, loosened the ribbon, and the hen, although left perfectly free, remained immovable, even when he attempted to rouse it.

Therefore Kircher affirms that the hen thinks the chalk-line a string by which it is bound as at its feet, notwithstanding that the ribbon has been loosened. This he attributes to the force of the animal's imagination.

In this way Kircher reports something which never took place, although his confirmation partakes of reality. He also places his assertions in that fatal category of "events viewed unequally," which plays such an important *rôle* in the history of human error.

As soon as I had recovered from my extreme astonishment at the magical effect which I perceived at the first experiment I made, I immediately rubbed out the chalk-line. My astonishment, mingled with satisfaction, returned for a moment, as I saw the hen remain motionless although the chalk had entirely disappeared. The chalk-line appeared just as unnecessary as at the first and following experiments. Certainly this might have resulted from an after-effect of the line. In order to inspect this more clearly, I performed my experiment so that I held the hen firmly for some time, and stretched out the head and neck as if I were going to draw the chalk-line, but in reality did not do it. And lo! the hen remained just as immovable as if the line had really been there!

It is therefore an actual fact that the chalk-line and ribbon are entirely unnecessary. What Kircher affirms relating to the imagination of the hens in regarding the chalk-line as a band which holds them, is only an "event viewed unequally," consequently no event at all. Observe that the only actual fact in Kircher's report is the motionless condition of the hen after the line has been drawn. While he takes this temporal coincidence without further investigation for an actual event caused by the hen's power of imagination, he reports a circumstance which really never happened, at least not in the way he thinks.

Through my simplified arrangement, without either chalk or string I have not only placed hens in this stupefied condition, but also geese, ducks, turkeys, and even a timid, unruly swan. This state makes the animals incapable of escaping, or even of changing their forced positions. This strange condition lasts often for a minute, indeed, frequently a quarter of an hour and longer, and is so intense that the animals can only be roused after repeated blows. Yes, the animals —as you have seen yourselves—can be turned over on their backs without awaking or showing the least resistance. When they are thus

moved one can frequently perceive that the head of the hen, as though held by an invisible hand, keeps its proper position, while the neck is twisted. At the same time, the foot on the side which did not come in contact with the floor when the animal was moved, is drawn up with the claws cramped, while the foot on the other side is stretched downward. So the hens remain, just as ours is here on the table, for a long time, breathing heavily, but otherwise completely motionless on their backs, until at last either by themselves or by some other means they are aroused and fly away.

My experience with simply holding down the necks and heads of the hens on the ground did not prove efficacious with all hens, and was more or less so with the same ones at different times and under different circumstances. Wild hens seem better for this experiment than those which have already been used and which are accustomed to be near people. Under all circumstances the success of my simplified experiment proves that the tying of the hen's feet, and the drawing of the chalk-line, as Kircher did, are entirely unnecessary. The moment when the remarkable change takes place concerning the capabilities of the hen's nervous system, appears to be at the stretching out of the head and neck, where possibly a slight mechanical extension of certain parts of the brain may take place, apart from the fear which the animal experiences at being held forcibly.

The chalk-line and the oppression of the tight band which are actually quite dispensable, appear, on the other hand, open to pure deception. I myself was deceived at first. We must only be careful not to stand still at "an event viewed unequally," as the unlearned do. For the complete dispensableness of the string and chalk-line does not prove its absolute indifference and ineffectiveness; and, on the other hand, the gentle, mechanical extension of the brain and spinal marrow, in consequence of the equalization of the curvature which takes place in the vertebral column at the forcible stretching out of the head and neck, is a very plausible thought, though not exactly a thoroughly well-founded one. There is nothing else to be done. We must patiently and circumspectly continue our investigation and experiment, in order to find the actual connection of the phenomena.

You see that firm, strict, natural investigation is no child's play. It demands simple and proportionate incidents, an insight, a circumspection and criticism, which the people who proclaim and testify to the reality of moving tables, flying guitars, self-playing pianos, rappings, etc., as spiritual manifestations, do not possess. Yes, if it were so easy and simple to discover new features of Nature, or only to find out natural scientific incidents, certainly every one could be an "investigator."

I might have occasion here to express the just indignation which the unscientific and frivolous man infuses into the mind of an investigator of Nature. But our limited time to-day has passed so quickly

that I will close with this remark: Above all, it is not my intention to express different frames of mind and subjective feelings, but—the next time — to complete the investigation of Kircher's "*experimentum mirabile.*" I do this, finally, in order to be able to follow it with a general experimental investigation of spiritualism and spiritual manifestations, which all those who are capable of an unprejudiced deliberation may find clear and comprehensible. Till to-morrow, then.

TONGUELESS SPEECH.

By W. J. YOUMANS, M. D.

MANY animals possess the attribute of voice, but man is the only one among them all capable of modulating voice into speech. This he does by changing the shape of the cavities of the throat, mouth, and nose, by the actions of the muscles which move the walls of those parts, and by the movements of the tongue. The latter organ is commonly credited with the most important share of the work; a distinction to which, as we shall soon see, it is far from being entitled.

The sounds of the vowels, in ordinary speech, are produced by a continuous expiration, the mouth being kept open, and the form of its aperture changing with the utterance of each. Certain consonants may also be pronounced, without interrupting the current of expired air, by alterations in the shape of the throat and mouth: *h*, for example, is the result of a little extra expiratory force; *s*, *z*, *sh*, and *j* in some cases, *th*, *l*, *r*, *f*, and *v*, may likewise all be produced by continuous currents of air forced through the mouth, the shape of the cavity of which is peculiarly modified by the tongue and lips. All the other consonantal sounds of the English language involve the blocking of the air-current in its passage through the mouth. In the case of *m* and *n*, it is prevented from issuing through the lips, and is forced through the nose; while the remaining consonants, termed explosives, such as *b* and *p*, are produced by shutting the passage in both mouth and nose, and forcing the vocal current through the obstacle furnished by the mouth, changes in the form of which give to each consonant its peculiarity.

This, in brief, is the explanation given by Huxley, of the formation of articulate sounds; and it will be seen that, while the tongue is intimately concerned in modifying the shape of the oral cavity, only a few of the sounds, such as those of *d*, *t*, *s*, *sh*, *l*, and *r*, and sometimes *g*, require its presence, and most of these even may be approximately sounded without it. In his "Elementary Lessons in Physiology," Prof. Huxley relates the case of a man, examined by him, whose tongue had been removed as completely as a skilful surgeon could

perform the operation, two inches and a half of the member having thus been lost. The stump could be seen occupying a position as far back as the anterior pillars of the fauces, forward of which point, when the mouth was open, it could not be advanced. Yet this person could talk with little apparent difficulty, giving most of the sounds with ease: *s* and *sh*, *l*, and *r*, and final *g*'s, were more or less imperfect, but *d* and *t* were the only ones completely beyond his power. Well-authenticated cases of a similar character have, from time to time, been recorded; a few of the more remarkable of which are given in the following pages.

Cutting out the tongue was a form of punishment frequently inflicted in ancient times. In A. D. 484, sixty Christian confessors of Tipasa, a maritime colony on the north coast of Africa, had their tongues cut out by order of Hunneric, the Vandal conqueror; but, in a short time, some of them at least were able to speak with such distinctness that they went about preaching again. Pope Leo III. is said to have suffered a similar mutilation in 799, and afterward regained his speech. In the sixteenth century, a band of French Protestants were condemned to have their tongues cut out before they were led to the stake. One of them, immediately after the execution of the sentence, repeated three times, "Le nom de Dieu soit béni!" (God's name be blessed). In another case, the martyrs spoke so distinctly after losing the tongue, that the executioner was accused of having failed to carry out the sentence.

The ability to speak, after being thus deprived of the tongue, was long accounted miraculous, and regarded as a signal mark of divine favor. Even as late as the present generation this view of the matter has been maintained, in spite of the fact that the accumulated experience of surgeons has demonstrated it to be an entirely natural result, with nothing miraculous about it.

Sir John Malcolm, writing from Persia in 1828, describes the case of a chief named Zâl Khan, who, coming into disfavor with the reigning monarch, was condemned to have his eyes put out. Failing in his appeal for a recall of this cruel sentence, Zâl Kahn "loaded the tyrant with curses," and, in return, his tongue was ordered to be cut out. This order was imperfectly executed, and the loss of half the member is reported to have deprived him of speech. Being afterward persuaded that, if cut close, he might be able to speak intelligently with the root, he submitted to the operation, and subsequently told his own story to Malcolm. These statements were long doubted, but, in 1857, they were fully confirmed by Sir John McNeill, whose inquiries in Persia, where this mode of punishment is common, led to the discovery of many instances of a similar nature. The belief is universal in that country, that excision of the tip of the tongue permanently destroys the power of speech, while its removal at or near the root leaves the victim a chance of regaining the ability to again speak his

mind. Surgeons are agreed, however, that, for the purposes of talking, the more there is left of the "unruly member" the better.

But, even after total extirpation of the tongue, persons have been known to retain the faculty of speech without serious impairment. A case of this character is related by Roland, surgeon to the French court in 1630. It is that of a boy who lost his tongue, when six years old, from gangrene, the result of an attack of small-pox. At the time he came under observation, three years later, all that remained of the organ was a slight, double prominence, flattened and attached to the floor of the mouth, extending from the inside of the chin to the oval aperture of the throat. This was composed of muscular tissue, divided by a line, and was like two little muscles, with a furrow between them. When it was pressed, or when the child spoke or swallowed, it swelled, gathered itself up, and retracted from side to side toward its middle, or from one side of the mouth to the other, like two leeches joined together. Roland believed these small bodies to be the remains of some of the muscles ordinarily employed in the movements of the tongue. This child's mouth was anomalous in other respects. The palate was considerably flattened, and the teeth were in a double row, the outer row being the milk-teeth, which had not been shed, and the inner row the permanent teeth, which had come up behind, and pointed inward. Both these conditions the French surgeon attributed to the absence of the tongue, which, by its upward pressure, tends to produce the concavity of the palate, and, by its forward pressure, to force the teeth into a vertical position. The entrance to the pharynx was of an oval shape, and unusually small. The uvula was long and thin, descending almost to the epiglottis, and the tonsils were as large as chestnuts. Notwithstanding the almost complete absence of any thing answering to a tongue, and the additional defects enumerated, the child was able to speak intelligibly. Bonami and Aurran have recorded similar cases in the "Memoirs of the French Academy of Chirurgery."

A still more remarkable example of the retention of the powers of utterance, after loss of the tongue, is that of Margaret Cutting, whose case was brought before the Royal Society of England in 1742, and again in 1747. This girl lost her tongue by what was supposed to be a cancer, when four years old. The disease first appeared in the shape of a small black speck on the upper surface of the tongue, and rapidly eat its way quite back to the root. One day, while the surgeon who had the case in charge was syringing the parts, the tongue dropped out, the girl immediately thereafter, to the great astonishment of those present, saying to her mother: "Don't be frightened, mamma; it will grow again." Three months afterward it was completely healed, with not a vestige of the tongue remaining. At the age of twenty this girl was carefully examined by several competent gentlemen, who report in the 44th volume of the "Philosophical Transactions" as follows, regarding her condition: "We proceeded to examine her mouth

with the greatest exactness we could, but found not the least appearance of any remaining part of the tongue, nor was there any uvula. . . . . Notwithstanding the want of so necessary an organ as the tongue was generally supposed to be, to form a great part of our speech, and likewise to be assisting in deglutition, to our great admiration she performed the office of deglutition, both in swallowing solids and fluids, as well as we could, and in the same manner. And as to speech, she discoursed as fluently and as well as others do. . . . She read to us in a book very distinctly and plain, only we observed that sometimes she pronounced words ending in *ath* as *et*, *end* as *emb*, *ad* as *eib*; but it required a nice and strict attention to observe even this difference of sound. She sings very prettily, and pronounces her words in singing as is common."[1]

The inability to speak, after loss or mutilation of the tongue, is sometimes due, not so much to the lack of that organ, as to the state of the sufferer's mind. Like those patients with impaired locomotive powers who, believing they cannot walk, seem to lose the power of will necessary to enable them to try to walk, the person with an imperfect tongue, laboring under the impression that talking is impossible, fails to make the necessary effort, and perhaps would never regain the faculty of speech unless startled into some involuntary exclamation that convinces him of his mistake. An amusing example of this accidental recovery of speech is quoted by Dr. W. Fairlie Clarke from the works of Paré. A rustic who had lost a portion of his tongue, and believed he could not speak, was tickled by a companion while he was in the act of drinking, when, in spite of his mental impression, words burst forth. "He attributed this to the use of the basin that he was holding to his lips; and, having by its means regained faith in his powers of utterance, he always carried a basin about with him, and applied it to his mouth when he wished to speak. . . . The effect of a nervous shock," says Dr. Clarke, "is distinctly seen in a case recorded by the celebrated Dr. Tulp, of a young man sailing in Italy, who was taken by pirates, and carried to Turkey. On account of his refusal to turn Mohammedan, his tongue was cut out. He was dumb for three years, but recovered his speech suddenly one stormy night, when he was terrified by a vivid flash of lightning which was followed by a loud peal of thunder."

In the cases thus far cited, speech was fully developed before loss or mutilation of the tongue occurred, and the other organs, having become perfectly educated, were subsequently able to assume and carry on the function. What is more remarkable still, not only can the tongue be spared after the power of speech has been perfected, but it appears to be quite unnecessary to the development of the faculty. This is shown by a case described by M. de Jussieu, the more interesting parts of whose narrative are given by Clarke, in his

[1] Quoted from W. Fairlie Clarke, "On the Diseases of the Tongue."

work on the "Diseases of the Tongue." The subject was a girl, born tongueless, in a village of Alemtejo, a small province of Portugal. The defect was first made known by her inability to suck, a difficulty that the mother obviated by pressing her breasts, and thus forcing the milk to flow into the infant's mouth while it held the nipple tightly between its lips. This girl was fifteen years old when first seen by Jussieu, who, after two careful and thorough examinations, thus describes the condition of her mouth: "I remarked only a small elevation, in the form of a mamelon, which rose in the middle of the mouth to the height of about three or four lines. This elevation would have almost escaped my observation if I had not assured myself of its existence by touch, for it was scarcely visible. In pressing it with my finger, I felt a sort of movement, of contraction and dilatation, which showed that, although the organ of the tongue was absent, yet the muscles which form it, and which are designed to move it, were present; for there was no hollow under the chin, and I could only attribute the alternating movements which I have described to these muscles. . . . Some persons, perhaps, who doubt the possibility of any one speaking without a tongue, may imagine that in the case of this girl it was not really absent; but that by some natural accident it was adherent to the lower or lateral portions of the mouth. But an inspection will at once remove this impression; for not only is its cavity larger than usual, but at the back the uvula is distinctly visible, and is seen to be more than double the usual length, and also a little thicker than ordinary. It stretches almost to the epiglottis, and forms at the back of the throat two equal rounded openings instead of one; while in other subjects the aperture, though single and larger than the two together in this case, can only be seen by pressing down the base of the tongue."

The function of speech was performed by this girl so distinctly and clearly that no one would have known, without being told, that the tongue was absent. She could clearly pronounce all the letters of the alphabet, as well as separate syllables, and complete sentences. It was observed, however, that some of the consonants, such as *c*, *f*, *g*, *l*, *n*, *r*, *s*, *t*, *x*, and *z*, were pronounced with more difficulty than the other letters, and that, when she had to utter them slowly and separately, the effort required to sound them was shown by bending her head forward, so as to bring her chin nearer to the throat or larynx, thus raising the latter and placing it almost on a level with the teeth.

The *Medical Record* quotes from the Canada *Medical and Surgical Journal*, for March of this year, a case of removal of the tongue and lower jaw of a man aged seventy-one years, in order to get rid of a cancerous mass that extensively involved those parts. Four months after the operation he was brought before the Medico-Chirurgical Society of Montreal; no great amount of deformity was observable, and "speech

was restored to some extent, notwithstanding the entire ablation of the chief organ which gave it articulate utterance."

"The singular fact," remarks Jussieu, "of a mouth which could speak though it contained no tongue, ought to convince us that the presence of a tongue is not absolutely essential to speech, since there are other organs in the mouth which contribute to produce articulate sounds, and which can supply the lack of it. The uvula, the nares, the palate, the teeth, and the lips, are all so much concerned in speech, that whole nations are distinguished by the manner in which they make more or less use of one or other of these parts."

THE LATE PROFESSOR JOHN TORREY, M. D., LL. D.

WHEN we proposed to present the portrait of Prof. Torrey in our gallery of eminent scientists, we little thought we should be called to speak of him, in our sketch of his labors, as of the past. For several years his health had been so delicate as to cause anxiety to his family and friends, and he each succeeding winter seemed to be more susceptible to atmospheric changes. Late last winter he had a severe attack of pneumonia, which left him so weak that he was unable to rally, and his death, which was in a measure sudden, occurred on March 10th.

Dr. JOHN TORREY was born in 1796, and was consequently, at the time of his death, in his seventy-seventh year. He was a native of the city of New York, having been born, if we mistake not, in John Street. We recollect hearing him say that, when a boy of some twelve years of age, he was sent of an errand as far as Canal Street, and that he considered it a great hardship to be obliged to go so far into the country after dark. He had in youth a strong liking for machinery, and at one time had the intention of becoming a machinist, but chemistry offered still greater attractions, and he finally concluded to study medicine. His mechanical talent was in after-years of great service to Dr. Torrey, as it enabled him to devise and construct various ingenious forms of apparatus for the illustration of his lectures. While quite a young man he entered the office of Dr. Post, then one of the leading physicians of the city. At that day physicians dispensed their own medicines, and it was the duty of the office-students to prepare the various powders, tinctures, etc., and put up the prescriptions for the patients. The writer has frequently heard Prof. Torrey refer to the great value this experience was to him in after-life, as it gave him an early training in chemical manipulation such as the medical students of the present day rarely acquire.

Dr. Torrey took his degree at the College of Physicians and Sur-

geons in New York about the year 1820. He never liked the practice of medicine, and did not try very earnestly to become established in it, and we find him, in 1824, entering upon the duties of Professor of Chemistry at the United States Military Academy at West Point. We may here remark that Dr. Torrey's scientific life was twofold. While he is, perhaps, best known to the world as a botanist, it was as a chemist that he found his remunerative occupation. From the time of his acceptance of the chair at West Point, up to the day of his death, he was engaged either in teaching chemistry or in some position to which his profound chemical knowledge adapted him. In 1827 he was called to the chair of Chemistry in the College of Physicians and Surgeons, which he occupied until 1854, and during a portion of this time he was also Professor of Chemistry at Princeton, where he was associated with Prof. Henry.

In 1854 the United States Assay-Office was established in New York, and Prof. Torrey was appointed assayer, a position of great responsibility, which he held at the time of his death. He was also consulting chemist to the Manhattan Gas Company, and was often engaged as adviser to establishments where chemical knowledge was required. In early life Prof. Torrey was an enthusiastic mineralogist, and the first and following volumes of *Silliman's Journal* contain important contributions made by him to this science. Before he had received his medical degree, Dr. Torrey became one of the founders of the New York Lyceum of Natural History, and was one of the eleven corporators named in the charter of that institution. Early in the history of the Lyceum he was elected president, an office which he filled for several years. In the first number of the Annals we find a botanical paper from him, and the earlier volumes of this publication are enriched by some of his most important contributions to science.

The botanical career of Prof. Torrey commenced while he was yet a student of medicine. His first botanical publication was "A Catalogue of Plants growing spontaneously within Thirty Miles of the City of New York." This was presented to the Lyceum in 1817, but was not published until 1819. This work, which consists of 100 pages, is now exceedingly rare, and chance copies offered at sales of libraries bring fabulous prices. We find quoted in this catalogue the names of those who were distinguished botanists half a century ago, the author acknowledging aid from Mitchell, Nuttall, Rafinesque, Eaton, Eddy, Le Conte, Cooper, and others. When we consider the youth of the author, barely twenty-one, we must regard this catalogue as a remarkable performance. Only those who have undertaken similar works can appreciate the amount of labor necessary to its production, and botanists who go over the same ground at the present day wonder at the completeness of this catalogue. It gives us some idea of the astonishing growth of the city to read in this catalogue some of the author's favorite localities, such as "Love Lane," "Bogs near Greenwich," and

"Swamp behind the Botanic Garden," places that have long been covered by paved streets and brick and brown-stone blocks. When we read that one rare plant is found "in sandy fields, above Canal Street," we get a glimpse of what the New York of the author's youth must have been. We have dwelt thus upon this catalogue, as it is the precursor of a list of most valuable botanical publications which we can here only enumerate in chronological order:

1820. "A Notice of Plants collected by Captain N. Douglass around the Great Lakes at the Head-waters of the Mississippi."—(*Silliman's Journal*, vol. iv.)

1823. "Descriptions of some New or Rare Plants from the Rocky Mountains, collected by Dr. Edwin James."—(*Annals of the New York Lyceum of Natural History.*)

1824. "A Flora of the Northern and Middle United States, or a Systematic Arrangement and Description of all the Plants heretofore discovered in the United States north of Virginia." Elliott's "Botany of South Carolina and Georgia" was being published in numbers at the time Dr. Torrey commenced this Flora, which, as he says in his preface, was intended as a "counterpart" to Elliott's work. Like Elliott's work, his was issued in numbers, and the first volume was completed in 1824. But one volume of this work was published, and, as a portion of the edition was destroyed by fire, it is now only rarely to be met with. It contains over 500 pages, and includes the first twelve classes of the Linnæan system, the species being described with a clearness and minuteness and the synonymy elaborated with a care not heretofore displayed in any work upon American botany. It was the first work in which our Northern grasses were treated in a thorough manner, and students of the *Graminaceæ* at the present day find this a most useful work of reference. At an early day the author foresaw that the Linnæan system must be superseded by the natural system of Jussieu. This consideration, together with the loss of a large part of the first volume, led him to abandon the work. In order to supply the immediate wants of students, he prepared a compendium, which gave brief descriptions of the plants contained in the first volume of the Flora and of those which would have been included in the second volume.

1824. "Descriptions of New Grasses from the Rocky Mountains."—(*Annals of the Lyceum.*)

1824. (Joint author with Schweinitz.) "A Monograph of the North American Species of Carex."—(*Annals of the Lyceum.*)

1826. "Compendium of the Flora of the Northern and Middle States"—a full, concise, and compact work, referred to above.

1826. "Some Account of a Collection of Plants made during a Journey to and from the Rocky Mountains in the Summer of 1820, by Edwin P. James, M. D., Assistant-Surgeon United States Army." This paper was read before the Lyceum in 1826, but was not pub-

lished until 1828. It is a memoir of some 80 pages, and enumerates 481 plants, many of which were new species. This was, up to the date of its publication, the author's most important contribution to science, and is even now frequently referred to by the student of our Western plants. Besides, it has an especial interest, as it was the first American work of any importance in which the arrangement was according to the natural system. The only earlier publication in which the natural system was used being a list by Abbé Correa, of the genera in Muhlenburgh's catalogue, arranged according to the natural orders of Jussieu.

1831. "A Catalogue of North American Genera of Plants, arranged according to the Orders of Lindley's Introduction to Botany." This was published both in a separate form and as an Appendix to an American edition of Lindley's work.

1836. "A Monograph of the Cyperaceæ."—(*Annals of the Lyceum.*)

1837. "New Genera and Species of Plants."

1838. "The Flora of North America, by John Torrey and Asa Gray," was commenced and published in numbers, and at irregular intervals, until the year 1843. Dr. Asa Gray, then a young physician in Western New York, who had already shown great acuteness in his investigations of the flora of the part of the State in which he resided, was happily associated with Dr. Torrey in this great undertaking of publishing a "Flora of North America." The work was suspended with the completion of the "Composition," and for sufficient reasons. Just at this time our Government began to explore its Western territory, soon greatly enlarged by the annexation of Texas and the acquisitions by the war with Mexico. New botanical material accumulated at an astonishing rate, and our chief botanists had to choose between continuing the Flora, and allowing these botanical treasures to pass into other hands. They wisely determined to devote themselves to elaborating the new material, knowing that this work would be contributing to the future flora of North America, which, from the enlarged possessions and more thorough exploration of the older territory, must be taken up *de novo*. Both authors have industriously worked at the collections brought home by the various government and private explorers; those wholly or in large part by Dr. Torrey are here enumerated.

1843. "The Flora of the State of New York," being a portion of "The Natural History of New York." This work is in two large quarto volumes, of over 500 pages each, and illustrated with 161 plates. The descriptions are all redrawn, elaborate, and in a somewhat popular style. It is a most striking testimony to the industry of the author, who, while engaged upon this work, and making important explorations incidental to it, was at the same time discharging his professional duties at the College of Physicians and Surgeons, and at Princeton.

1843. "The Report of Nicollet's Expedition" was published this year, with an appendix by Dr. Torrey, containing an account of the plants collected.

1845. "Catalogue of Plants collected by Lieutenant Fremont in an Expedition to the Rocky Mountains;" and, in the same volume, (Fremont's Report) "Descriptions of some New Genera and Species of Plants collected in Captain J. C. Fremont's Exploring Expedition to Oregon and North California, in the Years 1843 and 1844. By John Torrey and J. C. Fremont."

1848. "Appendix to Emory's Reconnaissance," giving an account of the plants, many of which were new, collected in this expedition.

1852. "Catalogue of Plants collected by Captain Howard Stansbury in his Expedition to the Valley of the Great Salt Lake of Utah."

1853. "Plantæ Fremontianæ; or, Descriptions of Plants collected by Colonel J. C. Fremont in California."—(*Smithsonian Contributions*, vol. vi.)

1853. "On the Darlingtonia Californica, a New Pitcher-plant from Northern California."—(*Smithsonian Contributions, loc. cit.*)

1853. "Observations on the Batis Maritima of Linnæus."—(*Smithsonian Contributions, loc. cit.*)

1853. "Description of Plants collected in Captain Marcy's Exploration of the Red River of Louisiana."

1854. "Botany of Captain Sitgreaves's Expedition to the Zuni and Colorado Rivers."

1855–'60. These years saw the publication of the Reports of the Pacific Railroad Survey. As the reports were not published in the order in which they were written, we enumerate them in the succession in which they occur in the volumes:

Vol. II. "Botany of Captain Pope's Expedition." "Botany of Lieutenant Beckwith's Expedition." "Botany of Captain Gunnison's Survey." In these three memoirs Prof. Asa Gray was joint author.

Vol. IV. "Botany of Whipple's Expedition."

Vol. V. "Botany of Lieutenant Williamson's Report."

Vol. VIII. "Botany of Lieutenant Parke's Expedition."

1859. "Botany of the Mexican Boundary Survey." This is by far the most voluminous of all the Government Reports.

1861. "Botany of Lieutenant Ives's Colorado Exploring Expedition."

We do not include here the contributions of Dr. Torrey to the memoirs of Prof. Gray and others, for which he frequently elaborated genera and families; nor do we enumerate his minor contributions to the sciences.

Nearly all of these memoirs are illustrated by engravings, and some of them profusely so. Dr. Torrey rarely attempted to give the portrait of a plant, leaving that to the professional draughtsman; but in all the sketches showing minute structure—that which gave the illustrations

their greatest value to the botanist—his ready pencil found frequent employment. He drew with great neatness and rapidity, and it was his custom to record his observations by means of sketches of remarkable distinctness and accuracy.

For several years subsequent to 1861 he was engaged in herbarium work. His removal to Columbia College, and the disposal of his most valuable collection to that institution, rendered it necessary that the accumulations of years, including numerous typical specimens, should be put into complete order. He entered into the drudgery of assorting, determining, labelling, and putting into the herbarium the mass of unarranged material, with the same industry and zeal that he brought to more congenial work. No other hands than his could have completed this important task, and botanists have reason to be grateful that he was spared long enough to put this, in some respects, the most important herbarium in the country, in proper condition for study and reference.

This work being completed, we find him, though advanced in life, again contributing to his favorite science, and, in 1870, "The Revision of the Eriogoneæ," the joint production of himself and Prof. Asa Gray, was published in the Proceedings of the American Academy of Arts and Sciences. Upon the return of Wilkes's exploring expedition, the botanical collections were divided between Drs. Torrey and Gray, except the Cryptogamia, which were given to several specialists. In this division Dr. Gray took the extra-American share, while those collected upon our Pacific coast were elaborated by Dr. Torrey. Before his memoir could be published, the civil war came on, and stopped all appropriations for such work. Last winter, the proposition to publish was revived, and the last botanical work of Dr. Torrey was to take up, during a rally from his fatal illness, this long-delayed manuscript of the botany of Wilkes's expedition, and prepare it for the press. Although his mind was as clear and his perceptions as acute as ever, his strength was unequal to the task. It will be published as a posthumous work, under the supervision of his intimate friend and associate of many years, Dr. Gray.

This enumeration of his scientific labors would be incomplete without reference to his great work in educating others in science. In the various professorships he held he was always to the students a loved instructor, and many now eminent in science can trace the commencement of their careers to the teachings of Dr. Torrey. Not only in the class-room, but out of it, was his influence constantly exerted, and he was always surrounded by a circle of young men who never came to him in vain for sympathy and encouragement. He gave to such what was better than pecuniary aid, comfort, hope, and help in its best sense. There is many a chemist, now standing high in his profession, who owes his position to his kindly aid, and scarcely a botanist in the country who has not been a recipient of favors from his ever-open hand.

As trustee of Columbia College and of Princeton, he was largely influential in giving scientific studies their proper prominence in these institutions. It was through his influence, more than to that of any other one person, that the "School of Mines" was established. He always took the liveliest interest in its progress, and its ultimate success was to him a source of great gratification.

A few years ago the botanists of New York and vicinity formed an association, to which they gave the name of the Torrey Botanical Club. The club, from small beginnings, became so large that it was thought best that it should become a chartered body, and an act of incorporation was granted, and Dr. Torrey was elected the first president under the charter. This election took place when he was too ill to attend the meeting of the club, and he never assumed the office.

When we come to speak of Dr. Torrey as a man, aside from his scientific work, we feel embarrassed. Were we to say all that we feel, those who did not know him might regard it as extravagant; and, if we are guarded in our expressions, those who knew him well might think we had not done him justice. Soon after his death, one who had known him long said to us, "He is the only man I ever knew of whom it could be said he was truly lovable." "Truly lovable" expresses his character more completely than any other words. However highly we who knew him well may estimate him as a man of science, there is something beyond and beneath this that we admire; and, when we recall Dr. Torrey, it is not as the patient chemist or the acute botanist, but as the friend. It rarely happens to one to possess the peculiar personal attractiveness that was his. There was something about him that invited confidence, and that in advance promised sympathy. When we come to analyze this influence, we are forced to conclude that it was his perfect unselfishness. It was this that drew to him the affections of persons in all walks of life, for there are few who have so many friends as he had, and we doubt that, in dying, he left an enemy behind him. A devoted Christian, he never obtruded his Christianity, but let it appear in his every relation in life. Belonging to a denomination that is by some considered exceedingly strict, he was most charitable for the opinions of those who believed differently; and, while he followed the injunction to "do good to those of the household of faith," he allowed no sectarian lines to shut others out from his sympathy and aid. His faith in Christianity was too deeply grounded to be troubled by any fear that science might lead astray. He followed science with a devotion second only to that to his religion. Knowing that all truths are compatible, and that the researches of the chemist, the geologist, the physicist, or the botanist, can never reveal any thing that will displace God as the author and controller of all, he kept up with the most advanced scientific thought of the day, and remained until the last a devout Christian scientist.

EDITOR'S TABLE.

AIMS OF SCIENTIFIC EDUCATION.

IN a leading article on "The Proper Study of Mankind," the *Nation* recently entered a protest against scientific education; and, as we think it gave its influence to strengthen a current misconception on the subject, it will be in our way to offer a few words of reply.

It is a common opinion, and one which the advocates of the old system of study do all they can to maintain, that Science means merely the physical sciences, which treat of heat, light, electricity, chemical substances, and rock formations; that the value of scientific knowledge consists in its application to arts and industries, by which wealth can be accumulated; and that scientific education simply means the extension of mining, engineering, medical and agricultural schools, while its advocates would be glad to have these overrun the country, and root out all other educational institutions. In other words, the friends of scientific education are constantly charged with being animated by a narrow and sordid utilitarianism. We protest against this view as a gross misrepresentation. Science is not a mere acquaintance with physical things—it is a method of knowing, and is as comprehensive as the phenomena of the world we live in. It is not merely knowledge, it is the most perfect form of knowledge, upon all subjects which it is possible to know. Science is the investigator of Truth—truths of all orders, and by all the mental operations through which truth can be established. The first fact about knowledge is, that it grows; it begins in the common observations and reflections of untaught minds, and gradually develops into clearness, certainty, and precision; is it grovelling utilitarianism to demand that the highest and most perfect forms of knowledge shall be employed in the work of mental cultivation? But few can now be found who will deny that the study of the sciences has great value for mental discipline, and we hazard little in saying that, if pursued systematically, they are capable of giving the mind a training that is more varied and complete than that afforded by any other class of studies. That the influential and representative advocates of scientific education rest its claims upon any grounds of mere selfish utility is not true. No class of men protest more vehemently than they against such low and unworthy motives. They certainly believe in the value of knowledge, and in the eminent value of scientific knowledge; but they hold to a broader and more liberal culture than their adversaries; for, while not rejecting the study of the past, they would enlighten and vivify it by a deeper knowledge of the present. Nor is it true that they are the enemies of literary studies, although the writer in the *Nation* makes them say of the student, "Literature he had better let alone." But they protest against what Dr. Whewell calls the "narrow and enfeebling education" of an exclusive literary culture; and they demand such a restriction of it as will allow room and time for more solid acquisitions and a proper discipline of the faculties that literature neglects. The strongest advocates of scientific education urge increasing attention to the study of English literature; and, more than that, many of them prove, by their fine command of the language, that they have by no means themselves neglected it.

And the writer in the *Nation* not only reaffirms the current error that scientific education can only afford

a narrow, utilitarian culture, but his main point is that it breaks down in presence of the higher human interests in which we are all mainly concerned. He declares of its expositors:

"It is assumed, in nearly all that many of them say about education, that it is with Nature only that man has to struggle in the pursuit of happiness; and that, if he can only discover what to eat, drink, and avoid, how mines may best be worked, and crops raised, and distance traversed, and storms foreseen, and the state of the market transmitted, he will have solved the problem of living. . . . It now begins to be discovered, however, that, no matter how successful we may be in wresting her secrets from Nature, or how familiar we make ourselves with her processes, or however conscientiously we may adapt our lives to her requirements, the best scientific education, after all, only half fits us for the battle of life, and for the simple reason that the battle has to be fought not only with hard, inexorable physical surroundings, but with very troublesome and mysterious social surroundings. In other words, in making a career, we have to deal with our brother man as well as with earth and air and water. Let us mine never so successfully, we have to settle with the crowd at the mouth of the shaft before we can carry home our earnings. Let us manufacture never so deftly, we have to establish a rule of distribution before our science or our dexterity does us any good. Let us build railroads as we may, we have to come to an agreement as to who shall work them, and what he shall receive, before they profit us. Heat, and light, and electricity, and steam, are great monarchs, but they cannot raise us out of grovelling barbarism, unless we can come to some understanding with our neighbors as to the ends and modes of living. The study of man, therefore, is really the most important of all studies, and must always continue to be so. Nothing can take its place in any *curriculum*. People must learn how to live in society before they can get any lasting benefit from science, and before they can have and retain any thing worth the name of art; and this they cannot do without observing human nature as it is, and without making themselves acquainted with the past experience of the race. Now, the past experience of the race is found in literature, and languages, and laws, and monuments, or, in other words, in things of which our physicists are apt to make light."

We entirely agree with the writer as to the supreme importance of the study of man and his relations, but we totally dissent from his method of studying them. What we want to know concerning man and society is the laws of their constitution and action, and this it is the proper business of science to ascertain. It is not the office of literature to elucidate natural laws. We have had the literary method in its full power for thousands of years, without dispelling the illusions and obscurities which have shrouded the nature of man and human society. Literature was both incompetent in method and destitute of all the necessary data. Before man and society could be understood, it was necessary first to have correct notions of the workings and order of Nature. Light could only be thrown upon the higher phenomena, as the lower were first explained. To the preliminary work, literature and the literary method contributed absolutely nothing. We owe entirely to modern science that whole series of preliminary revelations concerning the method and operations of Nature, by which it becomes possible to interpret the individual and social phenomena of man. And to science we owe not only the solution of the preliminary problems, upon which the higher depend, but we are also indebted to it for that long and severe discipline, in the quest of truth—that apprenticeship of centuries in the mastery of mental methods—which are necessary to engage with the most difficult of all investigations, the unravelling of the complexities of human nature and the social state. Is all this preparation to go for nothing? Are we to be told that science is incapable of carrying on its own work, and that the agency which was incompetent to begin it is still able to complete it? Undoubtedly "the past experience of the race is found in literature, and languages, and laws, and monuments,"

and they have their value, which men of science by no means deny; but we have man before us, and society around us, as living and present facts open to immediate inquiry. Why go back to the ages when such a thing as the order of Nature was not even suspected, to get opinions concerning the constitution of things which are displayed before our very eyes. It is true that the study of the past can aid in the understanding of the present; but it is a deeper truth that the study of that which comes within the range of actual experience is the only key to the understanding of the past—Science must be the interpreter of History. The nature of man; the laws of his physical, mental, and moral constitution; their interdependence and reactions; and how he has come to be what he is: the nature of social aggregations; the natural laws by which they are regulated, and how they have come to be what we see them—are strict and legitimate scientific questions, and are no more to be determined by the literary method than the constitution of the sun or the origin of species. Biology, psychology, ethnology, and anthropology, are the names of branches of knowledge, imperfect indeed, but firmly established, which have been created by modern science, and which have already thrown a flood of light upon the nature of man. The scientific knowledge thus obtained is also the only indispensable basis for understanding the constitution and course of human society; and, if the reader cares to understand *how* essential one of those sciences is to the proper understanding of social phenomena, we recommend him to read the article in the present number of the MONTHLY on the bearings of biology upon sociological studies.

We have seen that the assumption of the writer in the *Nation*, that science is confined to the lower sphere of physical phenomena, is altogether gratuitous; and that man and society, if they are ever to be understood, must in future be mainly studied by the method of science which seeks for the establishment of natural laws. On what ground, then, can it be pretended that the study of man and human interests does not fall within the compass of scientific education? The writer seems to take it as a foregone conclusion that science has nothing to do with "the proper study of mankind;" yet scientific education has been long urged by its ablest advocates upon the very ground that it has every thing to do with it. Mr. J. S. Mill, although no partisan upon this question, explicitly denies the position taken by the *Nation*. In his celebrated address at the University of St. Andrew's, in 1867, he said: "Scientific education, apart from professional objects, is but a preparation for judging rightly of man and of his requirements and interests;" and he advocated compendious methods of classical study to allow more science in the universities, with a view to this very object.

In an article published in an English review in 1859, discussing the worth and claims of different kinds of knowledge, and which is one of the most powerful pleas for scientific education that have yet appeared — an article which was translated into half a dozen European languages, and which has been republished in all shapes and a score of times in this country—the claims of scientific education were placed upon the distinctive ground of its bearing upon the highest human interests. We extract a closing passage:

"Thus, to the question with which we set out—What knowledge is of most worth?—the uniform reply is—science! This is the verdict on all the counts. For direct self-preservation, or the maintenance of life and health, the all-important knowledge is—science. For that indirect self-preservation which we call gaining a livelihood, the knowledge of greatest value is—science. For the due discharge of parental functions,

the proper guidance is to be found only in—science. For that interpretation of national life, past and present, without which the citizen cannot regulate his conduct, the indispensable key is—science. Alike for the most perfect production and highest enjoyment of art in all its forms, the needful preparation is still—science. The question which at first seemed so perplexed has become, in the course of our inquiry, comparatively simple. We have not to estimate the degrees of importance of different orders of human activity and different studies as severally fitting us for them; since we find that the study of science, in its most comprehensive meaning, is the best preparation for all these orders of activity. We have not to decide between the claims of knowledge of great though conventional value, and knowledge of less though intrinsic value; seeing that the knowledge which we find to be of most value in all other respects is intrinsically most valuable; its worth is not dependent upon opinion, but is as fixed as is the relation of man to the surrounding world. Necessary and eternal as are its truths, all science concerns all mankind for all time. Equally at present, and in the remotest future, must it be of incalculable importance for the regulation of their conduct, that men should understand the science of life, physical, mental, and social: and that they should understand all other science as a key to the science of life."

CLASSICS AS A PREPARATION FOR ENGLISH.

THE readers of the MONTHLY may recollect that, in his article in the April number, Mr. Spencer criticised the position taken by Matthew Arnold in regard to the needs of English culture. Mr. Arnold is a great admirer of the French Academy, which, he says, was established "to work, with all the care and all the diligence possible, at giving sure rules to our (the French) language, and rendering it pure, eloquent, and capable of treating the arts and sciences," and he thinks something of the kind would be of great service in England. Mr. Spencer pinted out the inefficiency and absurdity of such an attempt at supervision, and prepared a note to the article, which was not printed with it. We insert it here, as it has both a personal interest and a significance in relation to classical studies, as a preparation for English:

"Before leaving the question of Academies and their influences, let me call attention to a fact which makes me doubt whether as a judge of style, considered simply as correct or incorrect, an Academy is to be trusted. Mr. Arnold, insisting on propriety of expression, and giving instances of bad taste among our writers, due, as he thinks, to absence of Academic control, tacitly asserts than an Academy, if we had one, would condemn the passages he quotes as deserving condemnation, and, by implication, would approve the passages he quotes as worthy of approval. Let us see to what Mr. Arnold awards his praise. He says:

'To illustrate what I mean by an example. Addison, writing as a moralist on fixedness in religious faith, says:

"Those who delight in reading books of controversy do very seldom arrive at a fixed and settled habit of faith. The doubt which was laid revives again, and shows itself in new difficulties; and that generally for this reason—because the mind, which is perpetually tossed in controversies and disputes, is apt to forget the reasons which had once set it at rest, and to be disquieted with any former perplexity when it appears in a new shape, or is started by a different hand."

'It may be said, that is classical English, perfect in lucidity, measure, and propriety. I make no objection; but in my turn, I say that the idea expressed is perfectly trite and barren,' etc., etc.

"In Mr. Arnold's estimate of Addison's thought I coincide entirely; but I cannot join him in applauding the 'classical English' conveying the thought. Indeed, I am not a little astonished that one whose taste in style is proved by his own writing to be so good, and who to his poems especially gives a sculpturesque finish, should have quoted, not simply without condemnation but with tacit eulogy, a passage full of faults. Let us examine it critically, part by part.

"How shall we interpret into thought the words 'arrive at a . . . habit?' A habit is *produced*. But 'arrival' implies, not *production* of a thing, but coming up to a thing that preëxists, as at the end of a journey. What, again, shall we say of the phrase, 'a fixed and settled habit?' Habit is a course of action characterized by constancy, as distinguished from courses of action that are inconstant. If the word 'settled' were unobjectionable, we might define habit as *a settled course of action;* and, on substituting for the word this equivalent, the phrase would read 'a fixed and settled settled course of action.' Obviously the word *habit* itself conveys the whole notion; and, if there needs a word to indicate degree, it should be a word suggesting *force*, not suggesting *rest*. The reader is to be impressed with the *strength of a tendency* in something active, not with the *firmness* of something passive, as by the words 'fixed and settled.' And then why 'fixed *and* settled?' Making no objection to the words as having inapplicable meanings, there is the objection that one of them would be sufficient: surely that which is fixed must be settled. Nor are these all the imperfections in this short sentence. The habit referred to is the habit of *believing;* and to call it the habit of *faith* is to imply that the words *faith* and *believing* are synonymous.

"Passing to the next sentence, we are arrested by a conspicuous fault in its first clause—'The doubt which was laid *revives again*.' To revive is to live again; so that the literal meaning of the clause is 'the doubt which was laid lives again again.' In the following line there is nothing objectionable; but at the end of it we come to another pleonasm. The words run: 'and that generally for this reason, because the mind. . . .' The idea is fully conveyed by the words, 'and that generally because the mind.' The words 'for this reason' are equivalent to an additional 'because.' So that we have here another nonsensical duplication. Going a little further there rises the question — Why 'controversies *and* disputes?' 'Dispute' is given in dictionaries as one of the synonymes of 'controversy;' and though it may be rightly held to have not quite the same meaning, any additional meaning it has does not aid, but rather interrupts, the thought of the reader. Though, where special attention is to be drawn to a certain element of the thought, two almost synonymous words may fitly be used to make the reader dwell longer on that element, yet, where his attention is to be drawn to another element of the thought (as here to the *effect* of controversy on the mind), there is no gain, but a loss, in stopping him to interpret a second word if the first suffices. One more fault remains. The mind is said 'to be disquieted with any former perplexity when it appears in a new shape, or is started by a different hand.' This portion of the sentence is doubly defective. The two metaphors are incongruous. Appearing in a shape, as a ghost might be supposed to do, conveys one kind of idea; and started by a hand, as a horse or a hound might be, conveys a conflicting kind of idea. This defect, however, is less serious than the other; namely, the unfitness of the second metaphor for giving a concrete form to the abstract idea. How is it possible to 'start' a perplexity? 'Perplexity,' by derivation and as commonly used, involves the thought of entanglement and arrest of motion; while to start a thing is to set it in motion. So that, whereas the mind is to be represented as enmeshed, and thus impeded in its movements, the metaphor used to describe its state is one suggesting the freedom and rapid motion of that which enmeshes it.

"Even were these hypercriticisms, it might be said that they are rightly to be made on a passage which is con-

sidered a model of style. But they are not hypercriticisms. To show that the defects indicated are grave, it only needs to read without its tautologies one of the sentences thus: 'The doubt which was laid revives, and shows itself in new difficulties; and that generally because the mind which is perpetually tossed in controversies is apt to forget the reasons which had once set it at rest,' etc., etc. Omitting the six superfluous words unquestionably makes the sentence clearer—adds to its force without taking from its meaning. Nor would removal of the other excrescences, and substitution of appropriate words for those which are unfit, fail similarly to improve the rest of the passage.

"And now is it not strange that two sentences which Mr. Arnold admits to be 'classical English, perfect in lucidity, measure, and propriety,' should contain so many defects: some of them, indeed, deserving a stronger word of disapproval? It is true that analysis discloses occasional errors in the sentences of nearly all writers—some due to inadvertence, some to confusion of thought. Doubtless, from my own books examples could be taken; and I should think it unfair to blame any one for now and then tripping. But, in a passage of which the diction seems 'perfect' to one who would like to have style refined by authoritative criticism, we may expect entire conformity to the laws of correct expression; and may not unnaturally be surprised to find so many deviations from those laws.

"Possibly, indeed, it will be alleged that the faults are not in Addison's English, but that I lack the needful æsthetic perception. Having, when young, effectually resisted that classical culture which Mr. Arnold thinks indispensable, I may be blind to the beauties he perceives; and my undisciplined taste may lead me to condemn as defects what are, in fact, perfections. Knowing absolutely nothing of the masterpieces of ancient literature in the original, and very little in translation, I suppose I must infer that a familiarity with them equal to Mr. Arnold's familiarity would have given me a capacity for admiring these traits of style which he admires. Perhaps redundance of epithets would have afforded me pleasure; perhaps I should have been delighted by duplications of meaning; perhaps from inconsistent metaphors I might have received some now unimaginable gratification. Being, however, without any guidance save that yielded by mental science—having been led by analysis of thought to conclude that, in writing, words must be so chosen and arranged as to convey ideas with the greatest ease, precision, and vividness; and having drawn the corollaries that superfluous words should be struck out, that words which have associations at variance with the propositions to be set forth should be avoided, and that there should be used no misleading figures of speech; I have acquired a dislike to modes of expression like these Mr. Arnold regards as perfect in their propriety. Almost converted though I have been by his eloquent advocacy of culture, as he understands it, I must confess that, now I see what he applauds, my growing faith receives a rude check. While recognizing my unregenerate state, and while admitting that I have only psychology and logic to help me, I am perverse enough to rejoice that we have not had an Academy; since, judging from the evidence Mr. Arnold affords, it would, among other mischievous acts, have further raised the estimate of a style which is even now unduly praised."

"TOO MATERIALISTIC."

THE *Buffalo Commercial Advertiser* commends THE POPULAR SCIENCE MONTHLY, but thinks that "it tends

somewhat to a too materialistic nature in certain of its articles." The *Advertiser* is not alone in its objection; other newspapers, both religious and secular, frequently remind us that our pages are "too materialistic." As there seems to be so general an agreement upon this point, it is to be presumed that the subject is perfectly understood, and we have only to regret that our critics are not more explicit, and do not tell us exactly what they mean by *materialism*, and point out just how far we should go in that direction. If we are "too materialistic," how materialistic is it proper we should be?

By materialism can hardly be meant in this case that speculative doctrine which denies spirit, and affirms that every thing is matter, because we have not gone into that question at all, and it is hardly to be expected that our monitors would tolerate that in any degree. It must, therefore, be meant that we give undue prominence to material subjects and material explanations of things; but the importance they assume is certainly not our fault, for we are responsible neither for the existence of matter nor for the part it plays in the economy of the universe. Matter—"mere gross, brute matter"—may be very undignified and objectionable stuff, and, if some people had been consulted at the creation, perhaps it would have been left out altogether. But it certainly was not left out; it is here, whatever it may be, the foundation of existence, and not to be got rid of. We are all made of it; and each of us has to add several pounds daily to his personal stock, upon penalty of death for non-compliance. The mass of mankind, moreover, are doomed to work in it, shaping and transforming it in a thousand ways all their lives long. The very instruments and conditions of all our feelings, enjoyments, and thoughts, are material, while the Divine Power employs matter as the great medium of working out the laws of being and the harmonies of existence. It was said by Plato that God ever geometrizes; but it is still a profounder truth that God ever *materializes*. We, therefore, dodge the criticism about being "too materialistic," and leave our newspaper friends to settle their differences with the higher powers. Science is a knowledge of the laws of Nature, and nothing remains for us but to take Nature as we find it; and, as matter is mixed up with every thing, we cannot ignore it. There have been systems of thought in which the consideration of matter was allowed no place, but they have been futile and fruitless; science, on the other hand, is a system of thought which respects the order of things, and includes matter as the first and constant object of inquiry; and it has opened a new realm of truth, and changed the course of human affairs. After the world had been long dominated by philosophies that were full of contempt for matter—philosophies that were espoused by theology and accredited in the great seats of learning—it was not surprising that science, which declared matter to be an excellent thing, and quite fit to be studied, should have been denounced and resisted; but it *is* surprising that after science has made an intellectual epoch, and created a new and nobler future for humanity by the study of the divine laws as embodied in matter, there should still be those who mumble the exploded prejudices of the past, and make themselves miserable about the "too materialistic" tendencies of modern thought. Read Papillon's article in the present number of the MONTHLY, and see what "matter" means in the light of recent science.

And, speaking of materialism, here comes the London *Spectator*, with more talk upon the subject. This journal affects philosophy, and, for years, has been in the habit of branding with opprobrious epithets doctrines it did not

happen to like. It recently tried to fasten the imputation of materialism upon Mr. Douglas Spalding, on account of his psychological views; but that gentleman repelled the charge, and, apparently in much confusion over the subject, the *Spectator* now formally asks, "What is modern materialism?"—a question which it might better have settled, for its own guidance, some time ago. And the answer which the *Spectator* gives to its own question is certainly extraordinary. In the first place, it informs us what materialism is *not;* and, strange to stay, it declares that a belief in the materiality of the soul—that its qualities are physical, visible, or tangible, instead of spiritual—is not materialism. The editor says: "It is not properly, we think, materialism to believe, as some very eminent thinkers, and some very eminent and (in their day) orthodox ecclesiastics have believed, that the soul of man is a physical entity, existing only at some particular point of space." On the other hand, the *Spectator* affirms that the pure idealist, who goes so far as to deny the existence of matter, and to resolve all things into immaterial or spiritual agencies, may yet be a materialist. Hence, according to this oracle, he who believes in nothing but matter need not be a materialist; and he who believes in nothing but spirit may still be liable to the reproach of materialism. But, if materialism has nothing to do with the question of matter and spirit, in what does it consist? Why, according to the *Spectator*, it consists in believing that the universe unfolds from a lower into a higher state, and "that the higher order of phenomena are strictly dependent on the lower." Nor does it make any difference if the universe is held to have been caused and to be governed by a Creative Spirit; if that government proceeds by the method of a gradual unfolding from the lower to the higher, he who believes it is a materialist. And so, in the last exigency of polemics, an obnoxious term is wrenched from its strict and long-sanctioned significance to be used simply as a vehicle of opprobrium. The *Spectator* would have been equally honest and less absurd if it had compressed its article into two lines as follows: "What is modern materialism? A dirty label to be plastered upon the evolutionists."

LITERARY NOTICES.

PREHISTORIC RACES OF THE UNITED STATES OF AMERICA. By J. W. FOSTER, LL. D. Chicago: S. C. Griggs & Co., 1873, pp. 415, price $5.00.

IN briefly referring last month to the sudden and lamented death of Dr. Foster, we mentioned that he had just completed a new work on the prehistoric American races. A careful examination of the book has satisfied us that it is one of the most interesting and important contributions to American archæology that have yet appeared, and will take rank with the leading treatises upon the general subject by European archæologists. We had thought of making some extracts from the volume, but it is so full of interest, from beginning to end, as to make selection perplexing, and were it not for the restraints of copyright we should be tempted to run the whole work through THE POPULAR SCIENCE MONTHLY, as it contains just that kind of information, in clear, compressed, and intelligible form, which is adapted to the mass of readers. Although drawing upon various authentic sources for his facts, Dr. Foster was very far from being a mere compiler. He had an enthusiastic interest in the question, and pursued it by direct observation and extensive original inquiries. The author explains how he was attracted to the investigation, in the opening passage of his preface. He says: "In early manhood, when, for the first time, I gazed upon the works of that mysterious people known as the mound-builders, my mind received a class of impressions which subsequent years have failed to efface. These works are in the vicinity of Newark, Ohio; and, although not the most stupendous, are the most elaborate in the whole series. It was a bright summer's morning,

and the sunlight, streaming through the opening of the dense canopy of foliage above, fell upon the ground in flickering patches. A slumberous silence filled the air; and I confess that, as I traced out the labyrinthine system of earthworks here displayed, with its great circles and squares, its octagons, gate-ways, parallel roads, and tumuli, the whole spread over an area of several square miles, and as I speculated upon the purposes of their construction, and on the origin and extinction of the people by whom they were reared, I was profoundly impressed."

The first chapter of the work gives an excellent summary of the general argument on the antiquity of man, as illustrated by European evidences. The second chapter discusses the same question, on the basis of evidence furnished in the United States. Chapter III. opens the question of the mound-builders, and the geographical distribution of their works; and the fourth chapter treats of shell-banks and shell-heaps, and the character of the crania found associated with them. Chapters V., VI., and VII., amplify the discussion of the mound-builders, their enclosures, their arts and manufactures, and the character of their ancient mining. The cranial and anatomical characters of the mound-builders are dealt with in Chapter VIII., while Chapter IX. considers their manners and customs, on the basis of ethnic relations. The problem of the old American civilizations is here entered upon, preparatory to the question, "Who were the mound-builders?" considered in Chapter X. Chapter XI. summarizes the discussion of the unity of the human race; and Chapter XII. closes the work, by treating of chronometric measurements, as applied to the antiquity of man. The whole exposition is condensed into 400 pages, and the publishers have done their part, in the fine execution of the engravings, and the beautiful typography of the book.

FOODS. By EDWARD SMITH, M. D., LL. B., F. R. S. New York: Appletons, 1873, pp. 485, price $1.75.

WHEN the editor of this periodical was in Europe, in 1871, arranging with authors to write for the INTERNATIONAL SCIENTIFIC SERIES, he was assured, by good authority, that the ablest man in England to treat the subject of foods was Dr. Edward Smith. This gentleman had made important researches into the character and physiological effects of aliments, and his results were accepted among men of science as of great value. He was a Government Inspector of Dietaries, and had published several works upon Food and Diet. His services were secured for the undertaking, and the little treatise he has produced shows that the choice of a writer on this important subject was most fortunate, as the book is unquestionably the clearest and best-digested compend of the Science of Foods that has appeared in our language.

The excellent work of Pereira was published thirty years ago, and nothing better has been issued during the past generation; but the advances in our knowledge of the subject have been so great that it is now out of date, and is but rarely referred to. Dr. Smith's book is not only scientific but practical: besides explaining the nature and properties of foods, as determined by the chemist, he shows how they are altered in taste and digestibility by the operations of the kitchen; and presents the information in so simple and intelligible a form, that it may be apprehended by everybody. Dr. Smith's "Foods" is emphatically a book for the people; not a mere receipt-book, although it contains many excellent directions for the preparation and use of aliments, but a summary of facts and principles for those who desire to understand the subject. His classification is simple and comprehensive. The term *foods*, as he uses it, embraces all forms of matter that are introduced into the living system to carry on the vital processes, and his leading divisions are into solid foods, liquid foods, and gaseous foods. Part I., treating of solid foods, takes up first animal foods, which are grouped as nitrogenous and non-nitrogenous, and the vegetable foods are then considered under the same groups. Part II. treats of liquids—water, milk, tea, coffee, and the various beverages, including alcohols. Part III. treats of atmospheric air, from the alimentary point of view. As it costs nothing, requires no cooking, and is not passed into the stomach for digestion, air is not generally included among foods; but, as it is

more necessary to the vital processes than any other substance, and is honored with a special channel for introduction into the system, and is liable to such variation of quality as profoundly to affect the health, its treatment was necessary to give completeness to the plan of the work, and no portion of it will be found more interesting or important than this. Dr. Smith has enriched his volume by a series of graphical diagrams, which present to the eye the effect of various alimentary substances upon the pulse and respiration. This method of physiological illustration is of great value, and has been long in use among scientific men, as it brings into pictorial view, so as to be quickly comprehended and easily remembered, the results of long trains of investigation. This is the first time that the graphic method of illustration has been applied to this subject, for purposes of popular instruction. A little careful attention will be required at first, to get familiar with the mode of illustration, but for this the result will be found amply compensating.

ARRANGEMENTS have been made for the translation of the International Scientific Series into the Russian language, and the works are all to be published in St. Petersburg. Negotiations are also pending for the reproduction of the series in the Italian language. When this is done, each author will be read in six countries, and have payment for his book from six publishers. The works of Prof. Bain on "Mind and Body;" of Dr. Pettigrew, on "Animal Locomotion;" of Balfour Stewart, on "The Conservation of Energy;" of Prof. Marey, on "The Animal Machine;" of Herbert Spencer, on "The Study of Sociology;" of Prof. Amos, on "The Science of Law;" and of Dr. Carpenter, on "Mental Physiology," are now all in press, and will be soon issued, and are to be rapidly followed by other English, German, French, and American works, now in course of preparation.

SECOND BOOK OF BOTANY; a Practical Guide to the Observation and Study of Plants. By ELIZA A. YOUMANS. Pp. 310, 422 cuts. Price $1.50. New York: D. Appleton & Co.

THIS volume is a continuation of the method adopted by Miss Youmans in the "First Book of Botany," published three years ago; and its peculiarity is that it enforces the direct and systematic study of plants themselves. Her object is to make the study of Nature a means of mental cultivation—an end which can only be gained by familiarity with the objects of Nature, and for this our schools, as at present managed, make no suitable preparation. In her Introduction Miss Youmans says: "Our plan of general education includes not a single subject that can secure the mental advantages arising from the direct and systematic study of Nature. We do a great deal in the way of 'mental discipline,' but the order and truth of things around us are not allowed to contribute to it. We train the faculty of calculation and drill the memory in lesson-learning; but the realities of Nature find no place in our schools, as means of mental unfolding, for training in observation, and for working the higher faculties of reason and judgment, upon natural things. In short, for calling out the more important powers of the mind by actual exercise upon the objects of surrounding experience, our educational system makes no provision whatever. Neither reading, writing, arithmetic, grammar, nor geography, brings the mind into contact with Nature at all; and even the sciences of physics, chemistry, physiology, and botany, are usually acquired from books, and with so little regard to the real objects of which they treat, that, as means of mental improvement, they are of very slight service."

Believing that botany has special and preëminent claims to be introduced into all schools, as a means of training the faculties of observation and reason upon actual phenomena, Miss Youmans has shaped her method entirely to the attainment of this end. She holds that "like arithmetic, botany is only to be acquired by first mastering its rudiments. And as in arithmetic the student is compelled to exercise his mind directly upon numbers, and work out problems for himself, so in botany, if worth pursuing at all, it should be studied in its actual objects. The characters of plants must become familiarly known by the detailed and repeated examination and accurate description of large numbers of specimens. The pupil must proceed step by step in this

preliminary work, digesting his observations, and making the facts his own, until he becomes intelligent in regard to the common varieties of plant-forms and structures. It is because the text-books of botany hitherto in use fail to provide for and to enforce this thoroughness of introductory study of the characters of plants—fail in the very groundwork of the subject—that the present plan of study has been prepared."

Miss Youmans's books, therefore, bear the same relation to the vegetable kingdom that an art-gallery "guide" bears to a collection of pictures: in connection with them it is valuable and important; apart from them, of little use. To those who wish to *read* botany, or to acquire it by the usual method of lesson-learning, her books will be of small service; but, to such as desire to know the science itself in its facts and principles at first hand, and to become so intelligent in regard to vegetable forms that they can read them as they walk in the fields, like printed pages, the method of study that she has arranged will be invaluable. The object that she wishes to secure being mainly educational—the cultivation of independent observation and reason, as applied to objects of experience—she insists that the study must be commenced early, while the childish mind is in its perceptive stage and peculiarly alive to external things. The First Book is therefore adapted to young children and beginners, and deals only with those readily-observed characters of plants which can be examined with the naked eye. The Second Book begins where the First left off, and goes more thoroughly into the work; the use of magnifying-glasses and microscopes is now commenced, and observation becomes careful and complete. The schedule system is carried out in its application to the flower, and "the pupil is introduced to the leading principles by which plants are arranged, and set to making groups of those that most nearly resemble each other in important characters. He is here called upon to do his own thinking, and to form opinions as to the amount of resemblance between different plants. He has to decide whether a certain group of characters presented by this specimen is most like one or another group presented by other plants, and this leads on to the comparison and estimate of the relations of different groups with each other. It is thus that the discipline of the judgment and reason begins to be secured at an early stage of the study, and is continued with more and more completeness as it goes on."

A great deal is said by thoughtful educators about the need of the more direct and thorough study of Nature, but the difficulty has hitherto been, how to make it generally possible and practicable. These little Books of Botany show how it may be done, and provide for the doing of it. "They are guides to self-education, and are adapted for use in school or out, by teachers and mothers, whether they know any thing of the subject or not, and by pupils without any assistance at all." They set the pupil to work, guide him in his course, and bring him face to face continually with difficulties which it will require the exercise of independent judgment to deal with. Mistakes will of course be made, and effort will be necessary to correct them, but this is the sole condition on which the judgment of things is to be educated. The value of the study of natural history classifications as a means of higher mental discipline—not in books, but in the objects themselves which illustrate them—has been long recognized, and botany unquestionably affords the best facilities for obtaining it. Upon this point Miss Youmans remarks: "Its discipline is corrective of the most common defects of education, and is eminently applicable in forming judgments upon the ordinary affairs of life. Carelessness in observation, looseness in the application of words, hasty inferences from partial data, and lack of method in the contents of the mind, are common faults even among the cultivated, and it is precisely these faults that the study of botanical science, by the method here proposed, is calculated to remedy. That the habit of systematic arrangement, in which the study of botanical classification affords so admirable a training, is equally valuable in methodizing all the results of thought, is testified to by one of the most intellectual and influential men of our time, Mr. John Stuart Mill. He was a regular field botanist, and cultivated the subject with a view to its important mental advan-

tages; and his great work on logic took a form which could not have been given it if the author had not been a working naturalist as well as a logician. In the second volume of his "System of Logic" Mr. Mill says:

"Although the scientific arrangements of organic Nature afford as yet the only complete example of the true principles of rational classification, whether as to the formation of groups or of series, these principles are applicable to all cases in which mankind are called upon to bring the various parts of any extensive subject into mental coördination. They are as much to the point when subjects are to be classed for purposes of art or business, as for those of science. The proper arrangement, for example, of a code of laws, depends on the same scientific conditions as the classifications in natural history; nor could there be a better preparatory discipline for that important function than the study of the principles of a natural arrangement, not only in the abstract, but in their actual application to the class of phenomena for which they were first elaborated, and which are still the best school for learning their use."

THE SANITARIAN. A Monthly Journal, edited by A. N. BELL, M. D. New York: A. S. Barnes & Co. $3.00 per annum.

THE sanitary question is now uppermost in the public mind, and it is gratifying to see that the discussion of it is not going to be kept as a "mystery" in the medical profession. Every human being is concerned in this matter; and, if sanitary science has any suggestions to make, they must be made directly to the people themselves. This is what the periodical before us aims to do, and this it is doing well. The paper in the August number on the ventilation of the public schools of this city ought to be printed separately and placed in the hands of all the commissioners, trustees, inspectors, superintendents, and other officers connected with the schools—not excepting the janitors. The same number contains also the following articles: Cholera stamped out; Animal Refuse of Large Cities; Defective Drainage; Action of Tea on the Human System; Cholera; Morbid Effects of Alcohol; the Public Health; Editor's Table; Book Notices.

MISCELLANY.

Fish-Culture in New Zealand.—Last January a large quantity of salmon-eggs from English waters was shipped to New Zealand. They would reach their destination in 112 days, but it was a question whether they would bear so protracted a journey, though carefully packed and surrounded by ice. To determine this question, four boxes of ova, packed after the same manner as those sent to New Zealand, were deposited at the office of a London ice company. After the lapse of 112 days, these boxes were opened, and the temperature was then found to be 38° Fahr. "In one of the boxes," writes Mr. Buckland, "the eggs nearly all contained living fish; in another they were 'blind,' that is to say, no embryo could be seen in them. In all the boxes there was a certain percentage of eggs which had turned quite white. Some of these white eggs presented a curious appearance—namely, a spot exactly the color of a strawberry, which covered a third of the surface of the egg."

The experiment was on the whole satisfactory, and proves that salmon-eggs may be kept in a healthy condition for 112 days or longer. It is still a question, however, whether the rivers of New Zealand are suited for the cultivation of salmon. Some years ago 1,200 trout-ova were shipped to Victoria, and recently Mr. Buckland received from that colony a trout weighing 7½ lbs. If salmon thrive equally well in Australasian waters, this essay in "practical natural history" will be productive of immense benefits to the British colonies in the South Pacific at no distant day.

New Theory of Boiler Explosions.—A late number of the *American Artisan* has a paper by Dr. L. Bradley, on "The Dissociation of Water by Heat as a Cause of Boiler Explosions," in which the author very well shows that such accidents are in many cases produced, not by tension of steam, but by the explosion of oxyhydrogen gas. Dr. Bradley in the first place states very clearly the history of the law of dissociation, or the separation of a compound body into its elements by the force of heat. Under atmospheric pressure the two elements of watery

vapor, viz., oxygen and hydrogen, are dissociated at 1,298° Fahr. "If, therefore," says the author, "we heat a bar of iron to fully 1,298°, and place it over a globule of water upon an anvil, a blow with a hammer will elicit the detonation of a rifle; I have repeated this experiment often. The elements of the water dissociate by the heat, and instantaneously recombine in cooling, causing the detonation."

The degree of dissociation, as of evaporation, depends on the pressure: under four atmospheres (60 lbs.), the heat required for dissociation is 1,870°. But the question arises, If the vapor dissociates at these temperatures, why do not the gases instantaneously combine and detonate? The reason is plain: in the boiler the atoms at once become mixed with a volume of steam sufficient to render them inexplosive.

The condition requisite for the generation of explosive gas in a boiler is that vapor be in contact with a surface heated to 1,298°, or higher, according to the pressure, as we have seen. Now, this condition may occur in a boiler filled with water, owing to the property which that liquid possesses of assuming the spheroidal shape when in contact with a highly-heated surface. "It is, therefore, not difficult to conclude," says the author, "that, in case of very heavy firing, a thin film of vapor may form between the water and the boiler, and, when this is once formed, the heating of the boiler would be so rapid that nothing but the cooling process of dissociation, which would then commence, could save it from completely burning through."

Explosion would then occur whenever—1. The oxyhydrogen gas, as compared with the steam, *rises* to the explosive proportion; or, 2. When the steam, by condensation, *falls* to the explosive proportion. To make explosion possible, the proportion of oxyhydrogen gas to vapor must be at least as 1 to 7.

Scientific Education in England.—Sir Josiah Mason, a manufacturer of Birmingham, is about to found a scientific college in that town on a most liberal scale. It is intended to afford thorough systematic scientific instruction, specially adapted to the practical, mechanical, and artistic requirements of that great centre of manufacturing industry. Systematic instruction is to be given in mathematics; abstract and applied physics; chemistry, theoretical, practical, and applied; the natural sciences, especially geology and mineralogy, with their application to mines and metallurgy; botany and zoology, with special application to manufactures; and physiology, with special reference to the laws of health. The English, French, and German languages will be taught, but mere literary instruction is excluded. No principal, professor, teacher, or other officer of the college, is ever to be called upon to make any "declaration as to, or submit to any test whatever of, his religious opinions," and the institution is to admit all persons "without distinction of age, class, creed, race, or sex," to the popular lectures; while the regular course will be open to qualified persons of all classes, "especially the more intelligent youth of the middle class." This *Nature* calls "one of the most princely gifts yet made to posterity in England by one of her wealthy sons."

The Hotchkiss Revolver-Cannon.—Some trials were recently made, says the *Revue d'Artillerie*, at the Satory Polygon, with a revolving cannon, invented by Mr. Hotchkiss, and intended for the Italian Government. The special object of these experiments was to ascertain the mechanical value of this engine. This new arm (whose calibre is 1¼ inch) differs essentially from all other mitrailleuses hitherto brought before the public, particularly in this, that it discharges a small cast-iron shell with percussion fuse, the effects of which may be formidable at distances relatively considerable.

We will, at another time, present a complete description of this gun, but for the present must content ourselves with giving some details of the ammunition employed. This consists of a cartridge with shell attached. The cartridge proper consists of a soldered tube of tin, with one end closed to form a cup. This closed end is reënforced, within and without, by two iron caps, and fastened with three rivets to a broader iron plate, which forms the true base of the cartridge, bears the pressure of the gases, and affords a grip to the extractor. The

percussion cap is fixed in the centre of this iron plate. The cartridge will hold 3½ ounces of powder, with space for a thick felt wad between the latter and the projectile. The charge of powder employed at Satory was only 2½ ounces, the unoccupied space being filled with two disks of brown paper, laid over the powder and covered with wadding. The shell, which has a total length of 2½ calibres, has a jacket of latten covering a portion of its length, with grooves answering to the riflings of the gun. Its weight is 17½ ounces, and it contains a charge of 1⅜ ounce of powder. The whole cartridge, charged and primed, weighs 28½ ounces.

The shell does not appear to be held tightly enough in the cartridge-case; it can be detached by the hand with but little trouble, and there is reason to fear lest, when charged cartridges are transported in boxes, the shells may be separated from their sockets.

To obviate all accidents, the revolver-cannon was set *en batterie* at about 100 metres, or 328 feet, from the butte, the shells being charged and provided with thin percussion fuses. At first the exploded cartridges, when withdrawn from the cannon, were not at once dropped by the extractor; but this slight defect was in a few minutes remedied, and, during the remainder of the experiments, there was no further difficulty in working the piece. The cartridges were greased before being used.

They suffered no injury from the discharge, and could be recharged and used over and over again. One had opened along the soldering, but had not been rent, nor had any gas escaped. It could be used again, on being soldered anew. Only one cartridge missed fire, and even this went off at the third trial. Only one of the shells also failed to explode. Nearly all of them went through the target, and only exploded in the butte. One, however, burst on striking the target, and one exploded within the gun-barrel; but this latter mishap is not necessarily to be attributed to any irregular action of its fuse, for the shells appear to have been badly cast, and one of the walls, oftentimes, by reason of the eccentricity of the central void, is extremely thin.

Six shots were fired in succession in 12 seconds, the cartridges being set in place one by one; then 15 cartridges in 15 seconds, with the use of boxes previously supplied with a certain number of cartridges. The fire might be kept up for some time at the rate of 60 shots per minute—equal to 66 pounds of cast-iron shot off in that space of time. The firing is very regular, and the sighting does not appear to undergo any notable variation.

Each shell breaks up into 12 or 15 fragments, large enough to produce mortal wounds at a certain distance from the point where they explode. Most commonly its bottom-piece (*culot*) separates from the rest without breaking, though lines of cleavage may have been made in it beforehand.

A notable drawback is the rapid fouling of the gun by the shells, which is manifest after the first few shots, and quickly grows worse. Doubtless this is attributable to the bad quality of the latten forming the jacket of the projectile.

We should say that the mechanism of Hotchkiss's revolving cannon works with certainty and regularity, and that its ammunition would do good service, were the shell better fastened in the cartridge. This shell is an article of difficult and delicate manufacture, and of a rather high price. The cannon would doubtless produce formidable effects at ranges approaching those of field-artillery, and the explosive properties of its projectiles give it a great advantage over all other mitrailleuses, since the aim can be regulated by observing the points where the shells fall.

Fertilization of Flowers.—Mr. Meehan last year exhibited, at the Philadelphia Academy of Natural Sciences, a pear having fibrous instead of granular flesh, and a tough rind like that of the apple. He accounted for these phenomena by the theory that apple-pollen had impregnated a pear-pistil. At the meeting of the Academy held January 21st he exhibited an ear of Indian-corn which serves to confirm his hypothesis. As soon as the "silk," that is, the pistils, appeared, the pollen in the "tassel" of a quite different variety of corn was set in a bottle near it, the plant's own tassel having been cut away some time previously. Soon this tassel was taken away, and replaced by

another of a different species. The result was that *each grain* bore a resemblance to the grain of the two impregnating plants, the base having the color of the one, and the upper half the color of the other. Thus it is seen that one ovule may receive an impress from the pollen-grains of at least two separate plants, even though a considerable time intervene between the first and second impregnation.

Madeira as a Health-Resort.—That invalids, who visit distant climes in pursuit of conditions more favorable to health than they can find at home, are but too often led by false hopes, is an every-day observation. A writer in the London *Times*, who went out to Madeira last year for the benefit of his health, has proved the truth of this observation by his own experience, and labors to convince other invalids that they can find, nearer home, advantages every way superior to those enjoyed at Madeira. The temperature of that island is no doubt remarkably equable, the thermometer very rarely indicating under 60° or over 78°; but yet from the latter end of February up to the date of the writer's letter, the beginning of May, the weather was as unpleasant as could prevail even in England. During March there were keen, piercing winds, and occasional hot sun, and April was a succession of chilly, damp, and rainy days. Thus the patient is almost sure to lose, in the discomforts of spring, all the strength he may have gained during the summer and winter.

A Portuguese never condescends to let apartments, and the invalid must put up with the very imperfect accommodation of the hotels, where comfort and sanitation are entirely disregarded. The writer regards the Madeira climate as especially unfavorable to youthful invalids. Finally, it would appear that every obstacle is placed in the way of those who wish to return home from the island. The writer's conclusion is, that the chances of recovery for a consumptive are far better at home, surrounded by the conveniences and comforts of life, than in Madeira, where the only favorable condition is the climate, and where even that advantage is more than balanced by the storms of the spring season.

Lacustrine Dwellings in Germany.—The remains of ancient habitations raised on piles are of rare occurrence in Germany, and hence the discovery last year of the *débris* of such structures in the bed of the river Elster, near Leipsic, awakened a lively interest. The discovery was made by Herr Jentzsch, of the Geological Institute of Austria. The order of the visible strata at this point is as follows: At the base is found a layer of sandstone; on this a lacustrine clay. Both of these belong to the upper portions of the quaternary rock. In the clay are two beds containing the remains of plants, and among these are found leaves of the willow and oak, fruit of the *Acer*, and sundry other vegetal fragments. Above these occurs a layer of roots some inches in depth, which shows that the surface of the soil remained at this level for a considerable period. The uppermost layer, two to three metres thick, was produced by an inundation. The piles discovered by Jentzsch in the bed of the Elster are set in the clay and covered over with this silt. They are arranged in circles, with their lower ends pointed, and their upper extremities connected by horizontal ties of oak.

Among the animal remains found here are, the lower jaw of an ox, with its teeth, stags' heads, the long bones of some mammal yet undetermined, and shells of the *unio* and *anodon*. No traces of human remains have been found, though fragments of pottery and charcoal are met with; also two stone hatchets.

Industrial Occupations of Women.—The following notes of avocations followed by women in the United States, taken from the last census returns, give a curious exhibit of the extent to which woman is now invading provinces of industry which once were supposed to belong exclusively to the other sex: Agricultural laborers, 373,332; stock-herders and stock-raisers, 75; architect, 1; auctioneers, 12; barbers and hair-dressers, 1,179; clergy, 67; dentists, 24; hostlers, 2; hunters and trappers, 2; lawyers, 5; livery-stable keepers, 11; midwives, 1,186; physicians and surgeons, 525; scavengers, 2; sculptors, 4; teachers, 84,047; whitewashers, 391; bankers and brokers, 15; barkeepers, 70; boat-hands, 30; canal-

boat hands, 10; dray-drivers, teamsters, etc., 196; newspaper-carriers, 7; pilot, 1; undertakers, 20; bell-foundery operatives, 4; brass-founders, 102; brewers, 8; brick-makers, 74; carriage-trimmers, 32; charcoal and lime burners, 5; cigar-makers, 1,844; clock-makers, 75; curriers and tanners, 60; distillers, 6; engravers, 29; fishers, 35; gas-works employées, 4; gun and locksmiths, 33; printers, 1,495; shingle and lath makers, 84; tinners, 17; wood-turners and carvers, 44.

Effects of Freezing on Wine and Spirits.—Some experiments on the freezing of wines and spirits are recorded as follows by M. Melsens in the *Comptes Rendus* of the French Academy of Sciences. Brandy cooled to as low as *minus* 35° C. was pronounced exquisite, and some connoisseurs pronounced it all the mellower in proportion as the temperature was reduced. About — 30° C., alcoholic liquors, containing 50 per cent. of absolute alcohol, become viscid, syrupy, and sometimes opaline. The author solidified spirits (cognac, rum) at — 40° and — 50° C., and says that if they be then taken as ices, or sherbet, with a spoon, it is surprising what little sense of cold there is. A spoonful of this ice when placed on the tongue appears to be less cold than ordinary ices, and many persons who have tasted such frozen cognac or rum could scarcely bring themselves to believe that they had on their tongues ices which might be served on dishes of frozen mercury. In fact these ices must be reduced to — 60° C. before the one who tastes them pronounces them "cold;" and scarcely ever will any one pronounce them "very cold." The lowest temperature at which M. Melsens experimented with these frozen alcoholic liquors was — 71° C. If a considerable quantity at that temperature be taken into the mouth, the effect is like that of a spoonful of soup a little too hot. In this case a wooden spoon must be employed, one of metal producing a blister. Placed upon the dry forearm this solid *eau de vie* produces a slight cauterization, without burning, as would a fragment of solid ether or carbonic acid.

The author's experiments on wines were undertaken with a view to discover the means of preserving them. On placing them in a vessel surrounded with a freezing mixture, they were reduced to the condition of a mass of ice-crystals permeated with a colored fluid. This he transferred to a wire sieve, and, by agitating it there, expelled the liquid. The ice on being melted was found to be tasteless, with the merest traces of alcohol. Thus the percentage of alcohol in the wine when deprived of its water is increased, and its keeping quality greatly improved. The author suggests freezing as a method of improving the body of light wines, which otherwise will not bear transportation, and says that if in France wine-growers will adopt the plan of heating their wines in order to check the "diseases" to which they are subject, and of freezing them, so that they may keep, the trade in wine will be rendered far less fluctuating than it now is. It will be possible to keep on hand a large quantity of wine, so as to offset the effects of bad harvests.

What Darwinism means.—From our esteemed contemporary, the *Lens*, of Chicago, we take the following correction of current misapprehensions as to the true meaning of Darwinism: "Prof. Edward S. Morse," says the *Lens*, "delivered, early in March, two lectures in Chicago, the one with the title 'From Monad to Man,' the other on 'Evolution.' In the lecture on 'Evolution' Prof. Morse makes two statements worthy of special note. In the one he alleges that the prejudice against Darwin, and the ridicule so freely expended upon him, are based on an entire misapprehension. Darwin has never taught that man is a development from a monkey, or from any lower species. Nor is there any thing in his philosophy that even admits of inference to this effect. He simply teaches, or suggests the probability, that man or monkey is simply 'evolved' from a lower basis of life. The several streams, all starting from one source, as they branch—the one goes to the monkey, and there stops; and the other to man, and there stops. It is not Darwinism that man himself, or the monkey itself, shall keep on till there is development into something higher and different. The other statement was to the effect that science deals with phenomena, not with the intelligent cause.

It notes and defines law; has nothing to do with the creator of the laws. Science, therefore, cannot take the place of religion. And when the man of science passes from the law to the author of law, he drops the character of scientist and assumes to teach religion. The scientist is not, therefore, censurable for restricting himself exclusively to the phenomena, making no reference to the power lying behind phenomena."

A Hoarding Bird.—A writer in *Hardwicke* has discovered in the nuthatch, or nut-pecker, the habit of laying up in its harvest-season a store of nuts for a winter provision, a characteristic which has been hitherto observed, as the writer remarks, in no other birds save tame individuals of the family *Corvidæ*. One day last September a nuthatch was seen to light upon a potato-hill, and there to drop something, which it drove into the earth with repeated taps of its beak. On investigation a nut was discovered there, and soon after six other nuts were found buried in close proximity to it. Again, so late as November 1st, the same bird was seen to bury a nut in a flower-bed, and, in the depth of winter, if watched, he will be found to visit frequently his hoards, taking with him, from time to time, so much as he needs for his present wants.

Artificial Respiration in Snake-Poisoning.—The publication of Dr. Fayrer's work on the *Thanatophidia* of India has led to a very active investigation of the subject of snake-poisoning. The author himself has made several experiments on the efficacy of artificial respiration as a means of counteracting the venom. In one of these he kept the heart beating for nine hours after the development of fatal symptoms. The heart then failed only from imperfect respiration carried on in the cold. If there is an analogy, as Dr. Fayrer supposes, between snake-venom and curare, there is every reason to expect that the remedy (respiration) which is effectual in antagonizing the latter will be equally effectual against the former.

Dr. Richards, of Balasore, thus details an experiment, made by himself, where the heart's action was kept up for 24 hours and 35 minutes: "This is, perhaps, the most remarkable case of its kind on record. The dog was, to all appearances, dead when the artificial respiration was commenced. Two hours and a half later convulsive movements were excited by the application of the galvanic current, but at seven o'clock there was no response, and the body of the dog was cold. At this time the eyes presented a glazed appearance, being perfectly dry. The pupils were dilated, and the heart was beating feebly. Had artificial respiration been now stopped the heart would have ceased to beat almost at once."

At noon the next day the dog appeared as if it would recover. "The eyes had lost the glazed appearance, lachrymation was restored, and there were winking of the lids on dropping water into the eye, attempts at deglutition when water was put into the mouth, and the heart was beating vigorously."

As artificial respiration must be kept up for hours, or even for days, Dr. Fayrer recommends the use of a special apparatus for this purpose, to be worked by steam.

NOTES.

One of the chief attractions of this year's International Exhibition in London is Mr. Buckmaster's School of Cookery, where lectures are given twice a day on culinary processes, fully illustrated by practical experiments. It is found impossible, with the present arrangements, to accommodate all who apply for admission to the lectures. Special attention is given to the best modes of preparing canned meat, a valuable food-stuff, against which Britons have very strong prejudices. There is certainly room for improvement in the popular culinary processes in vogue the world over, but nowhere perhaps is this improvement more needed than in English-speaking countries. We waste an enormous amount of good provisions.

The sound of the salutes fired by the British iron-clad fleet at Spithead on Monday, June 23d, in honor of the Shah's visit, was heard at Tedstone, Worcestershire, distant from Spithead 100 miles. A correspondent of the *Times*, writing from Tedstone on the 23d, says: "We have all heard a long continuous series of sounds, shaking the windows on the south side of the house, and resembling exactly the effect of a distant salute. My gardener states that he heard similar sounds between 11 and 12. My house is on a hill, from 400 to

500 feet above sea-level. On referring to the *Times* of Saturday, with to-day's programme, I find that the time (2.15) may coincide with one of the general salutes at Spithead, though at this distance it seems almost impossible that the vibration should be felt. We are familiar with the sound of salutes, from frequent summer visits to Stoke's Bay. I send the facts for what they may turn out to be worth."

In connection with the shortest railway route to India, *via* the Persian Gulf, an Englishman, resident in Damascus, suggests as worthy of consideration the ancient Roman causeway, which, it is said, exists, in an almost perfect state, from Bozrah in the Hauran, to Bassorah on the Persian Gulf. The roadstead of Acre might easily be formed into a good port, to serve as the Mediterranean terminus of the road.

Prof. Ferrier has obtained a grant from the Royal Society of London, which will enable him to pursue his studies on monkeys. He has already made some progress in these researches, as may be seen from the following passage taken from a letter written by Dr. Lauder-Brunton to the editor of the *Philadelphia Medical Times*. "Already his experiments on his Simian cousins have commenced," writes Dr. Brunton, "and the results are most satisfactory. He can make an animal follow his command by simply touching different parts of the brain, by the electrode, and 'eyes right,' 'eyes left,' 'eyes open,' 'eyes shut,' 'mouth open,' 'mouth shut,' 'tongue out,' 'tongue in,' etc., follow as certainly as the machinery of a London penny steamer follows the commands, 'ease her,' 'stop her,' 'back her.'" Whereupon the *Medical Times* observes that "it certainly looks equally for Prof. Brown-Séquard's theory of the origin of brain-symptoms."

According to the *Scientific American*, a Canadian inventor has originated a method of producing from the milk-weed, or other plants of the genus *Asclepias*, as also from flax and other seeds, a gum designed to serve as a substitute for India-rubber. The substances are macerated and fermented, and the liquid is then reduced, by evaporation, to a thick, gummy mass, possessed of many of the valuable qualities of rubber.

An "Acclimatization Society," for the introduction of singing-birds, as also of birds serviceable to the gardener and farmer, has been founded in Cincinnati. During the past spring the expenditure of the society amounted to $5,000, and fifteen European species of birds were introduced. The sky-lark is already acclimated at Cincinnati, and in the country around the summer air is vocal with his cheerful song.

From a microscopical examination of the blood of 143 lunatics, by Dr. H. Sutherland, of London, it appears that the blood in the insane generally contains an excess of the white corpuscles, and that its red corpuscles frequently show no tendency to arrange themselves in rouleaux. The coexistence of these two abnormal characters in the blood indicates, according to Dr. Sutherland, a very low degree of vitality. In ten men, suffering from general paralysis, whose blood was found to exhibit one or other or both of these conditions, five died within three months after their blood was examined.

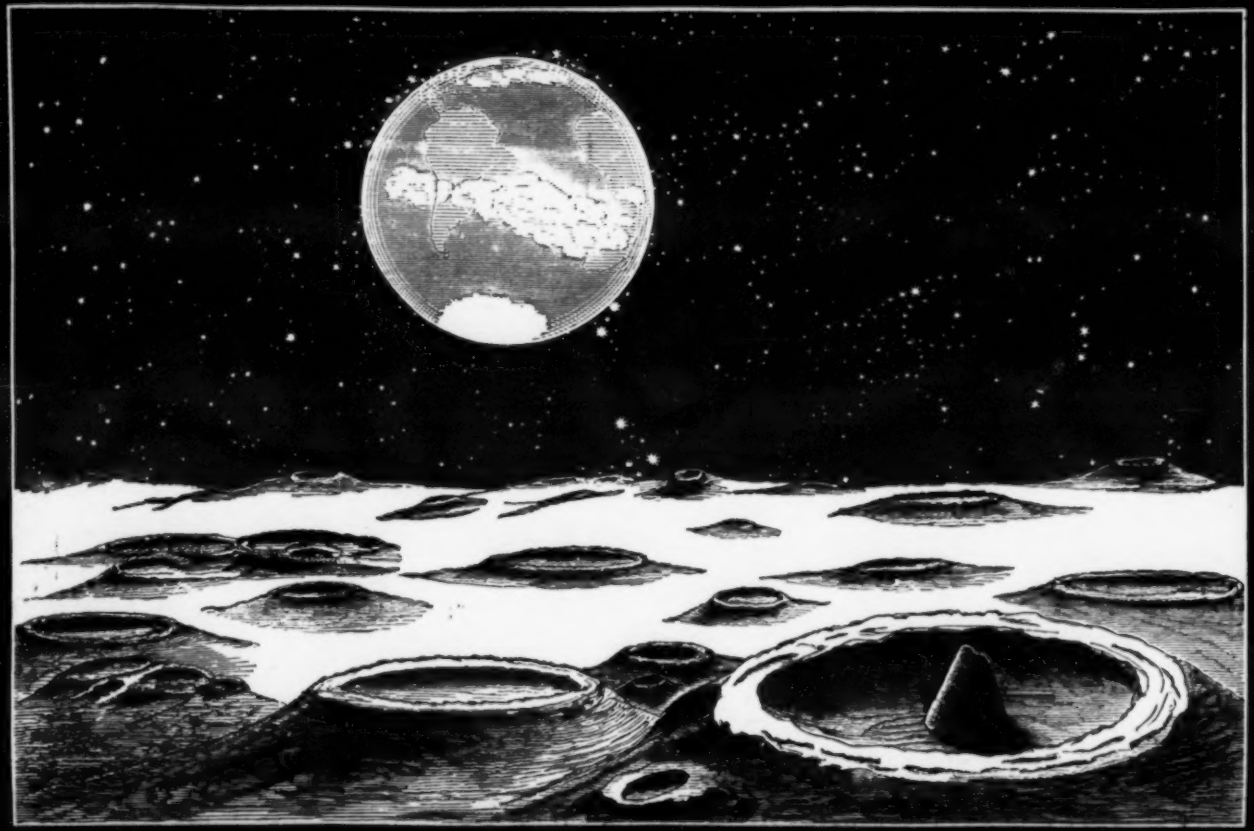
Notwithstanding that during the past few years great efforts have been made both here and in England to put a stop to commercial frauds and adulterations, the evil still continues almost undiminished. For instance, it is estimated that the milk vended in English towns is impoverished to the extent of at least 25 per cent. on the average; in some cases the impoverishment amounts to as much as 50 per cent. But the most glaring fraud of this kind on record was recently perpetrated in Ireland. Two milk-dealers were arrested in Dublin and convicted of selling milk containing, in the one case, 60, and in the other 75 per cent. of water.

Herr Eimer has recently found on a precipitous rock near the island of Capri a new species of lizard. It is blue all over, with dark spots on the back, while all the lizards in Capri are of a bright green, with only a little blue at the extremities. The rock is destitute of vegetation, and of a blue color. When at rest the lizard is hardly visible, its color being so like that of the rock. The rock, which is frequented by birds of prey, was at one time connected with Capri, and the blue lizards are supposed by Herr Eimer to be descended from the green, but transformed by natural selection to blue.

"A Constant Reader" wishes to know how to pronounce the name of the author of "Physics and Politics," Mr. Walter Bagehot. We gave the pronunciation of the name in a notice of the book in the February number. It is not Bag-hot, or Bag-shot, but Baj-ote, the *a* being sounded as in *badge*.

M. Merget, of the Paris Academy of Sciences, has solved the problem of producing indelible photographic proofs. He employs for this purpose salts of platinum, palladium, and iridium, reducing them with vapors of mercury, iodine, and hydrogen. The proof so obtained is absolutely unalterable, no matter how long it may be kept, as it contains no substance which can be affected by light.

PLATE XXI.

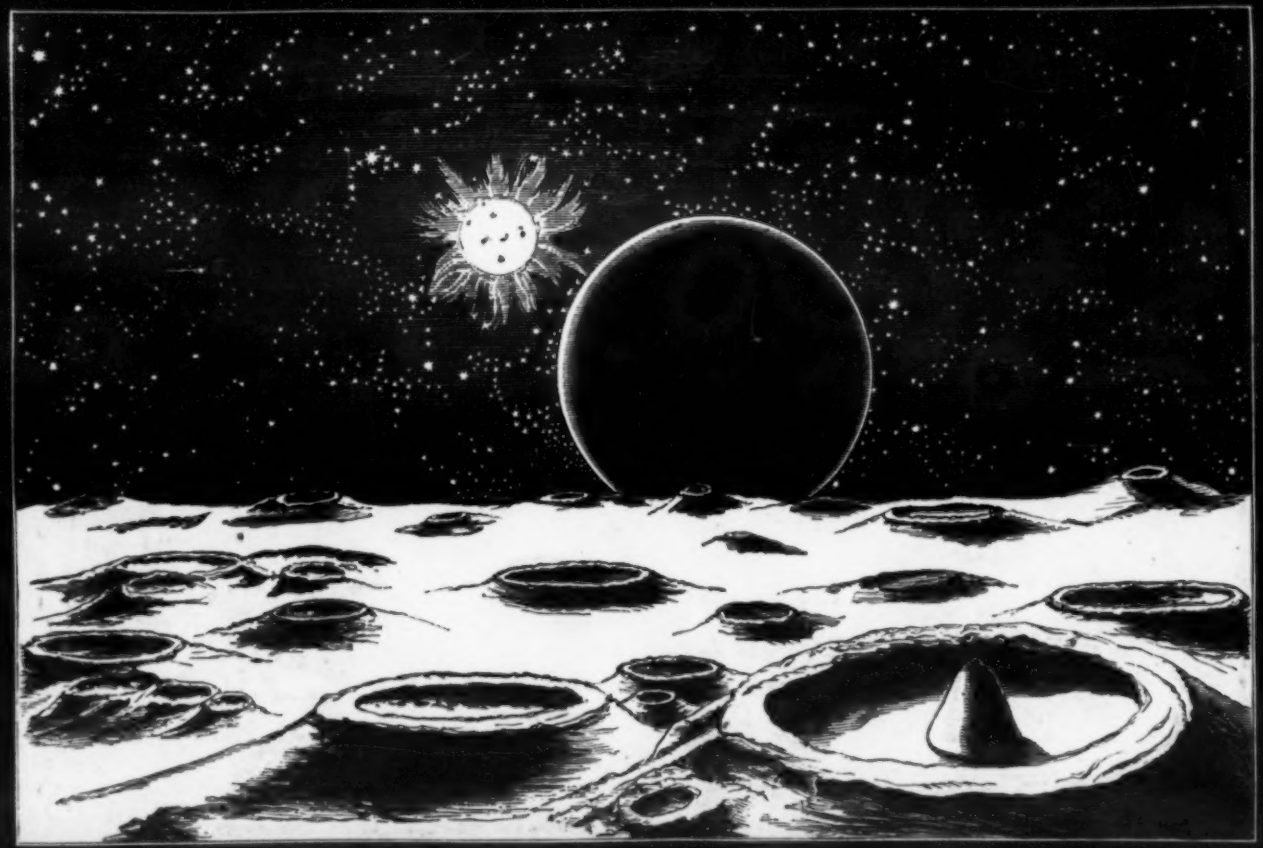


LUNAR LANDSCAPE—"FULL" EARTH.

PLATE XXII.

LUNAR LANDSCAPE—"FULL" EARTH.

PLATE XXII.



LUNAR LANDSCAPE—"NEW" EARTH.